Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1955

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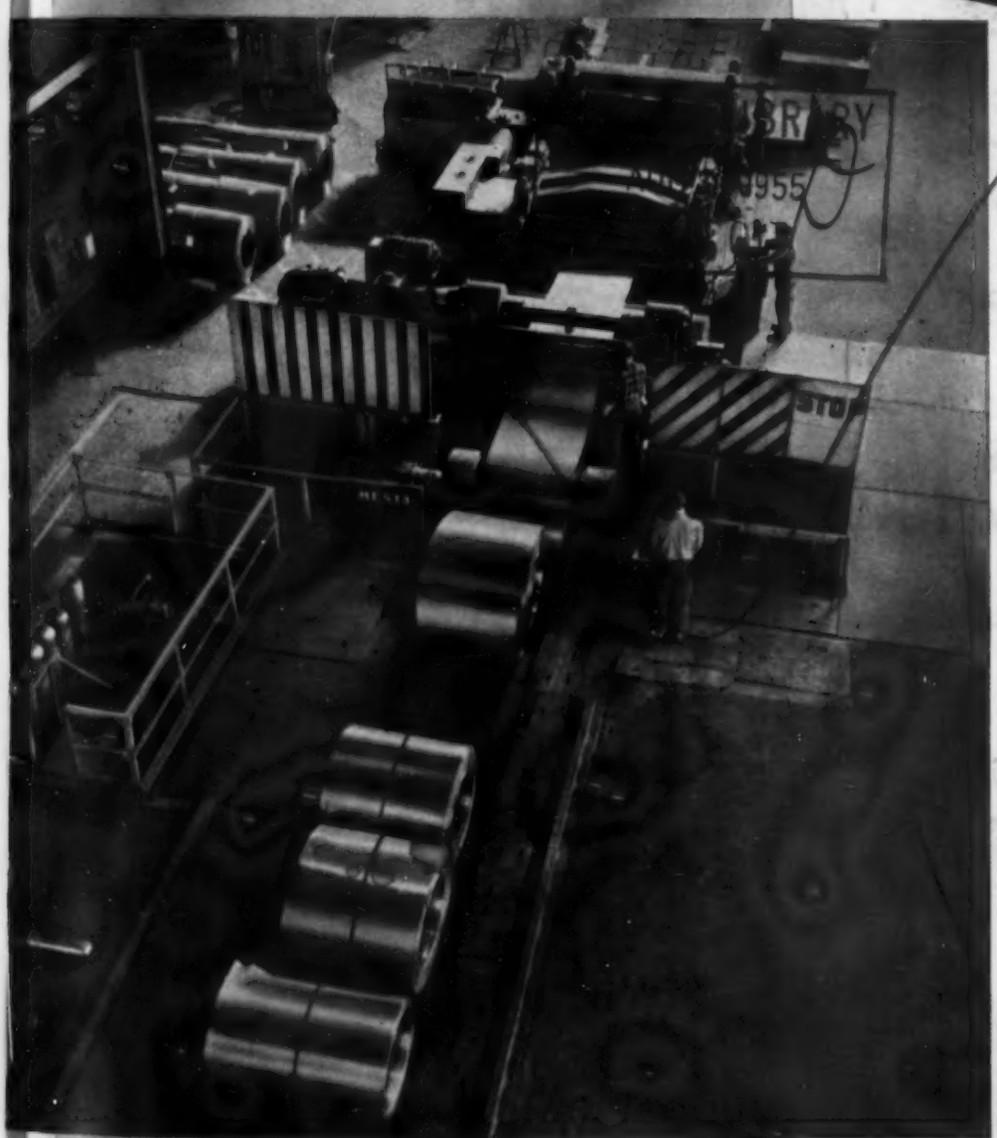
Shearing* LINES

TECHNOLOGY DEPT.

Designed and Built by MESTA



* HIGH-SPEED SHEARING, SIDE TRIMMING AND SLITTING EQUIPMENT FOR SHEET AND TIN GAUGE STRIP STEEL

MESTA 93" SHEET SHEARING LINE WITH TRIMMER AND COMBINATION FLYING SHEAR AND LEVELLER

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

WHAT'S NEW IN MOTOR CONTROL? ★ ★ ★ GET IT FIRST IN CUTLER-HAMMER

Now industry's three-phase motors can have full three-phase protection with standard in-stock motor control!

Many motor users have proved *two* overload relays are inadequate protection for three-phase motors. In fact, widespread motor burnouts due to inadequate motor protection have caused amendment of Section 4327 of the National Electrical Code. The code now permits authorities to *require* three overload relays in three-phase motor control . . . and this provision is already being enforced in some areas. Many safety experts and power engineers say the time is not far off when three-phase motor control with less than three overload relays will be unacceptable.

The use of three overload relays is not new. Many industrials plagued by recurring motor burn-outs and the resulting intolerable operating interruptions have changed to three-relay control. But such changeovers have been slow to effect and costly as no standard control was available with three overload relays. Special constructions and enclosures have always been required.

The BIG news today is that this is no longer true. The new Cutler-Hammer ★ ★ ★ Motor Control offers *three* overload relays in all standard starter constructions and enclosures. You pay only for the third relay, nothing additional for special engineering or manufacture. No extras. No delays. It is *in stock* at your nearby Cutler-Hammer Authorized Distributor. Order it today and use it tomorrow. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wis.

CUTLER-HAMMER
★ ★ ★
MOTOR CONTROL
C-H

For designers of machines and special control panels

The unit panel construction of Cutler-Hammer ★ ★ ★ Motor Control makes it easy to incorporate starters with three overload relays. Starters mount in place with only three screws, require no more space than starters with only two overload relays. NEMA Sizes O, 1 and 2 starters and all parts thereof are now available as components. Also a complete companion line of control relays with quickly interchangeable NC-NO contacts. Be sure you have the latest design data on this advanced equipment. Write or wire today.

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

THIS IS AETNA-STANDARD

SEAMLESS TUBE MILLS

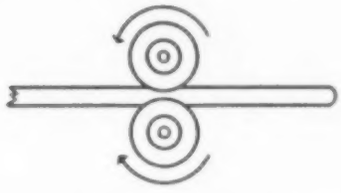
Aetna continues to conceive many new ideas for the production of seamless tubing. This continued progress, plus reputation and experience, helps Aetna-Standard to continue as world's leading designer and builder of Seamless Tube Mills.

ROLLS

Aetna specializes in manufacture of small and medium-sized iron-base rolls. Aetna is pioneering in the use of Nodular Iron for rolls and castings under trade name of Magaloy.

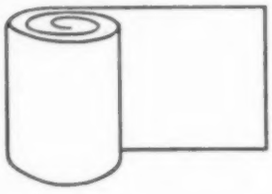
FLAT-ROLLED FINISHING EQUIPMENT

This is one of Aetna's six major product lines. Flat-rolled embraces such equipment as: Shearing and Classifying; Scrubbing and Drying; Recoiling; Slitting and Side Trimming; Roller Levellers (two-high and four-high); Reels of all kinds; and many other products.



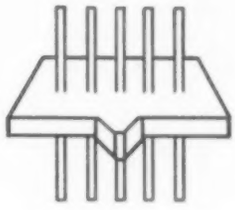
CONTINUOUS BUTT WELD PIPE MILLS

Over the years, new ideas and engineering accomplishments have strengthened Aetna's position as the only builder in America of Continuous Butt Weld Pipe Mills. In recent months, Aetna Pipe Mill equipment has been installed in America, in Canada, in Germany, in England, in Japan and in Argentina.



CONTINUOUS COATING

This year Aetna will have completed the building of 25 continuous galvanizing lines, in addition to several terne and electrolytic tinning lines. Aetna has worked closely with industry in this development and is considered the pioneer in continuous coating equipment.



COLD DRAWING

The world over, Aetna-Standard is recognized as the leading authority and builder of cold draw equipment for tubes and bars. This year marked introduction of several innovations by Aetna, such as the air gripper carriage and hook.

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

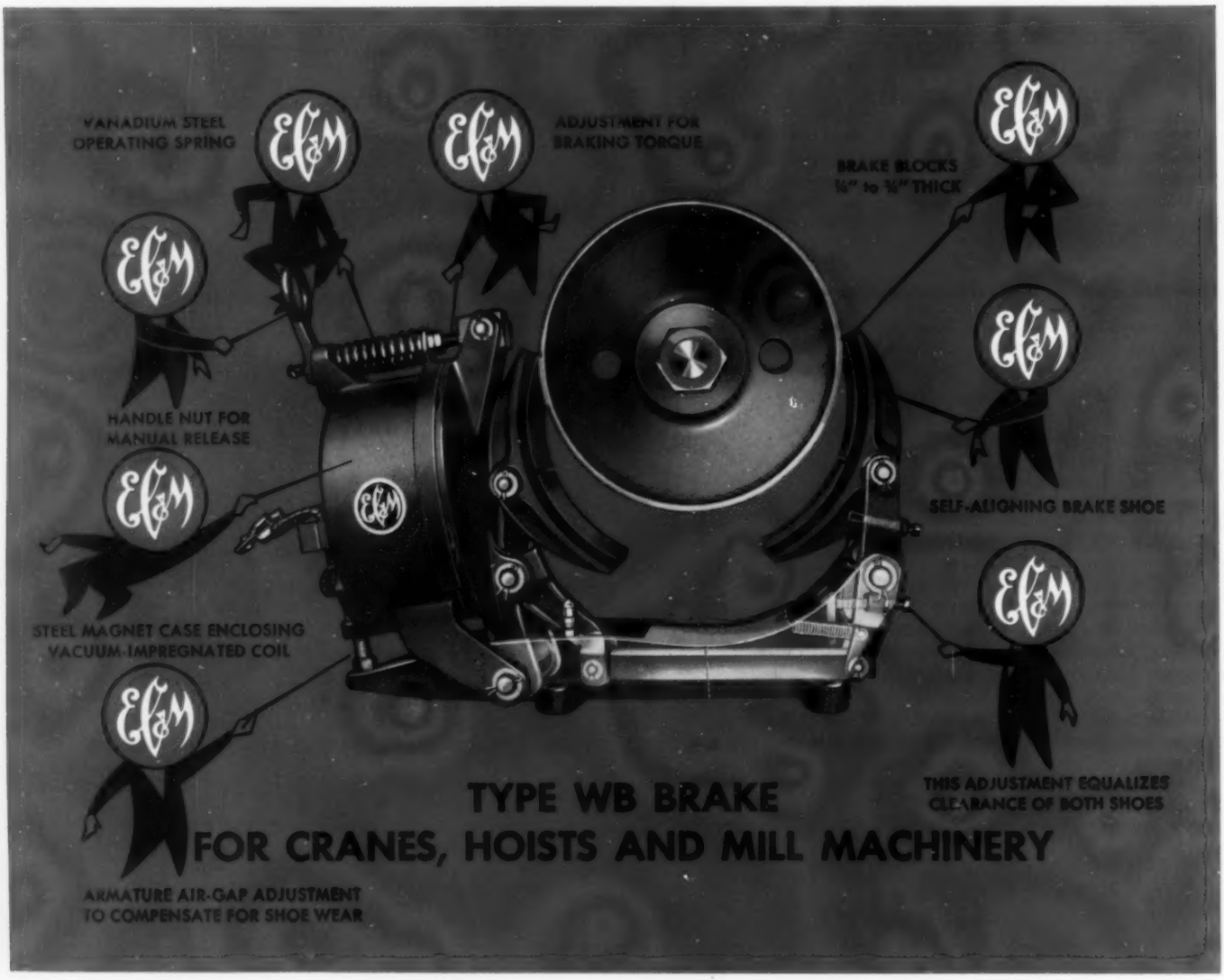
GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England— Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

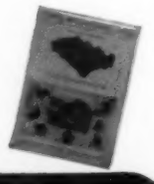
EC&M brakes are built for smoother operation • safer stops • less maintenance


VANADIUM STEEL OPERATING SPRING
ADJUSTMENT FOR BRAKING TORQUE
BRAKE BLOCKS ¼" to ½" THICK
HANDLE NUT FOR MANUAL RELEASE
SELF-ALIGNING BRAKE SHOE
STEEL MAGNET CASE ENCLOSING VACUUM-IMPREGNATED COIL
THIS ADJUSTMENT EQUALIZES CLEARANCE OF BOTH SHOES
TYPE WB BRAKE
FOR CRANES, HOISTS AND MILL MACHINERY
ARMATURE AIR-GAP ADJUSTMENT TO COMPENSATE FOR SHOE WEAR

Take a close look at the world's finest heavy-duty brake. Built for both alternating and direct current motors . . . Type WB Brakes are available in 7 sizes for D-c and 4 sizes for A-c operation.

EC&M has combined the finest materials and workmanship with years of experience and engineering research to assure trouble-free service. When you need a brake that is "performance proven" . . . a unit that provides smoother operation, safer stops and less maintenance . . . specify EC&M Type WB Brakes.

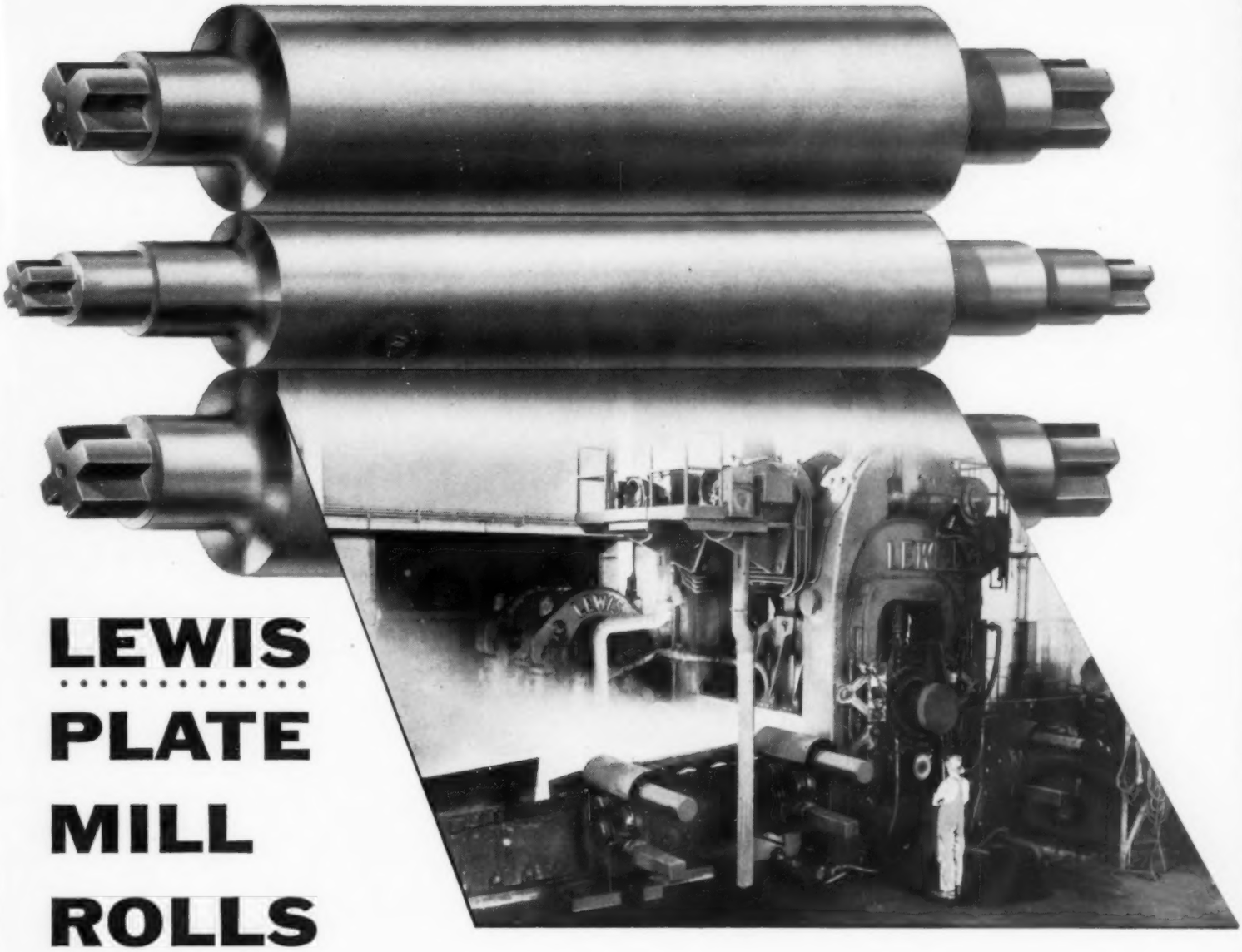
Write for literature today.



2046

THE ELECTRIC CONTROLLER & MFG. CO.

4498 LEE ROAD • CLEVELAND 28, OHIO



LEWIS PLATE MILL ROLLS

Operators have always found that Lewis Rolls are tops in quality—they always provide greater productivity at lower tonnage cost.

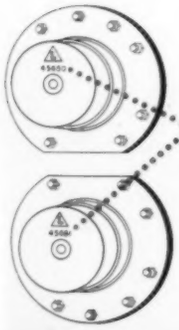
Plate mills equipped with Lewis Rolls are constantly operating at top production levels. Downtime is at a minimum, and costs of tonnage rolled are invariably low. Their uniform high quality is the result of controlled manufacture from raw materials through melt and pour to the final finished matched rolls.

Always get the best . . . specify and use quality Lewis Rolls in your operations, whether for roughing, intermediate or finishing stands. They save you money in the long run.

99 YEARS OF ROLL MAKING

Superior "X" Rolls • Ajax Duplex Rolls Lewis "X" and "XA" Rolls • Special Process Rolls • Climax and Ajax Rolls • Plain Chilled Rolls • Special Tube Mill Rolls • Atlas, Atlas "B" and Atlas "X" Rolls • Molybdenum Chilled Iron Rolls . . .

Rolls for Slabbing Mills, Billet Mills, Bar and Rod Mills, Merchant Mills, Plate Mills, Hot and Cold Strip Mills, Tube Mills



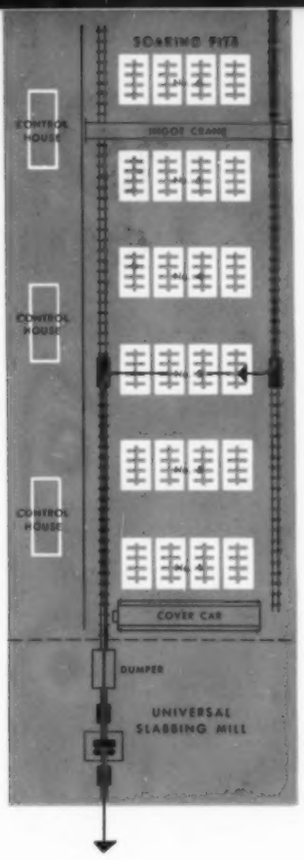
Matched Rolls Mean Greater Tonnage

LEWIS ROLLS

BLAW-KNOX

BLAW-KNOX COMPANY • Rolls Division
Lewis Rolls Department • Pittsburgh 1, Pa.

at Great Lakes, too...



high-production soaking pits

. . . a convincing example of 'Surface' leadership. Behind the story of these 24 soaking pits at Great Lakes Steel, Detroit Division of National Steel Corporation, is an imposing record of achievement: Surface Combustion has built 80% of all new pits since World War II.

At Great Lakes, six batteries, four 'Surface' pits in each, heat low carbon steel ingots for automotive and appliance steel. They also heat some low alloy steel ("NAX" grade). Capacity will be still further increased by the addition of 16 new single 'Surface' pits now being built.

These one-way-fired pits include such 'Surface' features as the efficient jet pump recuperative system, and integrated temperature and combustion controls which are of the most modern design. The performance of these pits, and many others, is among the reasons why steelmakers depend on 'Surface.'

SURFACE COMBUSTION CORPORATION, TOLEDO, OHIO

Surface
STEEL MILL FURNACES

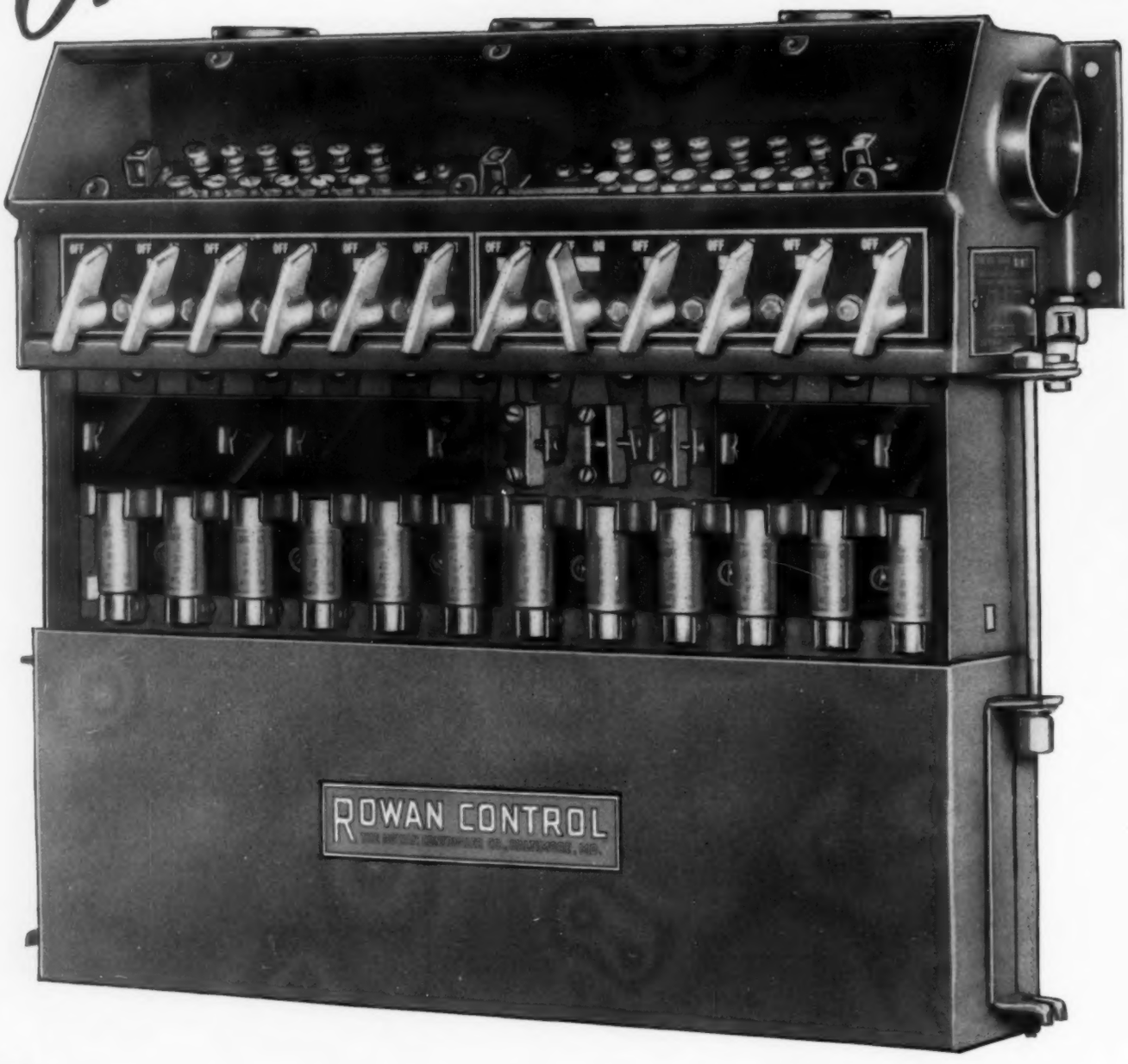
Foreign affiliate companies:

British Furnaces, Ltd., Chesterfield; Stein & Atkinson, Ltd., London

Stein & Roubaix, Paris, Liege, and Genoa; Chugai Ro Kogyo Kaisha, Ltd., Osaka

Benno Schilde Maschinenbau, A.G., Bad Hersfeld (Hessen, Germany)

Oil Immersed Series 800-834
LIGHTING SWITCHES



ROWAN Series 800 — 834 Lighting Switches are available in 6- and 12-gang units designed to meet the requirements of NEMA Type XI Enclosures. Internal mechanism is readily accessible for inspection and maintenance. Solderless type, adjustable connectors are provided for line and load connections. Units are equipped with extra heavy, self-aligning, quick make and quick break, renewable contacts. Rowan AIR-SEAL fuses provide time-tested and thoroughly proven short circuit protection.

Complete information is available from Rowan Representatives located in principal cities of the United States.

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

2 High Hot Strip Mill Table Rolls in plant of Dominion Foundries and Steel Ltd., Hamilton, Ontario, Canada. Arrows indicate location of J-M Clipper Oil Seals which protect bearings against dirt and other adverse conditions.

Engineers at Dominion Foundries and Steel Hot Strip Mill report:

"Bearings better protected— damaging dirt sealed out with Clipper Seals"

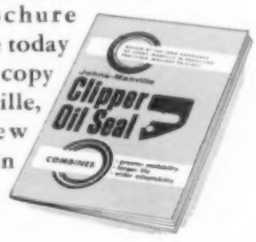
TABLE ROLLS of the 2 high strip mill at Dominion Foundries and Steel Ltd. must operate efficiently despite severe service conditions. Life of the Roll Bearings is constantly threatened by dirt and salt from strip mill operations.

To provide better protection, engineers replaced the original bearing seals with J-M Clipper Oil Seals. Long after this installation was made, Clipper Oil Seals are still providing far better bearing protection than the material formerly used. They seal out mill scale, salt and other foreign matter which might work into the bearing housings. They remain efficient despite high oil and air temperatures. They protect bearings by assuring clean lubrication.

Clipper Oil Seals offer many advantages wherever accurate fit, longer life and greater sealing effectiveness are required. These precision-moulded oil seals provide easy installation because the tough, dense heel affords just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

Made in both split and endless types, Clipper Oil Seals are available in a wide variety of designs, to meet practically any sealing requirement.

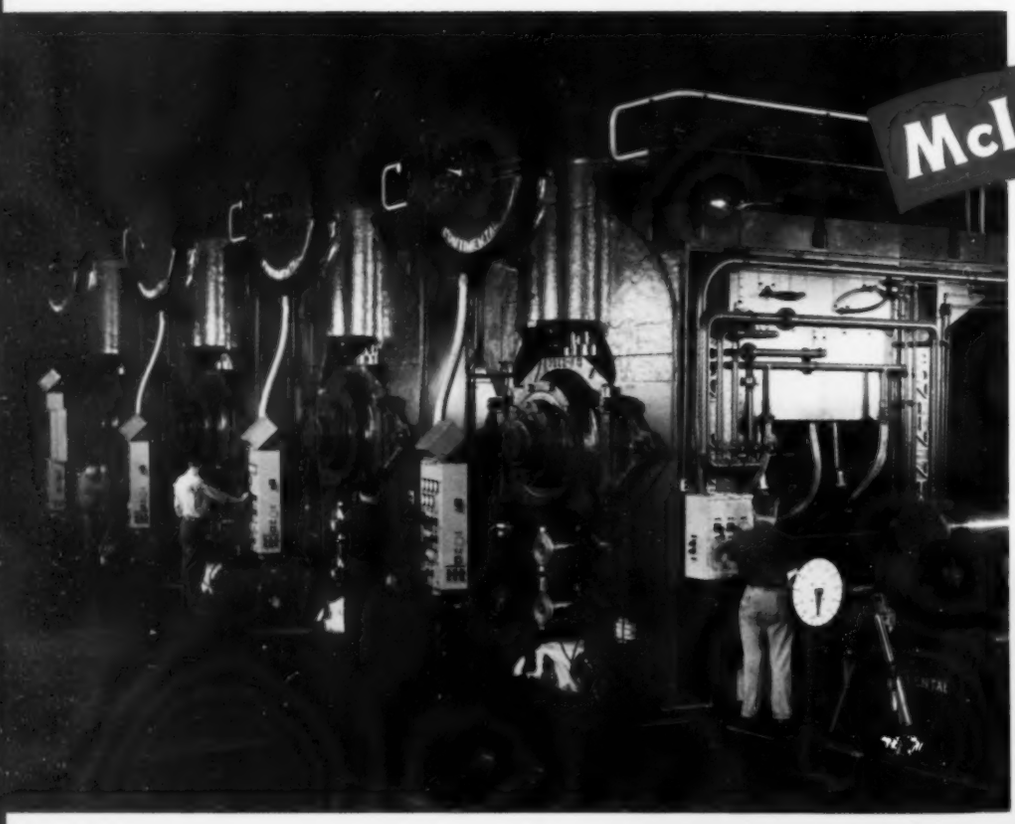
More details on this Dominion Foundries application as well as other interesting case histories, design data and complete information on all types of Clipper Seals are found in the new 28-page brochure PK-71A. Write today for your free copy to Johns-Manville, Box 60, New York 16, N.Y. In Canada, Port Credit, Ont.



JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER OIL SEALS

Proved by the customers



McLouth

A recent installation for the Gibraltar Plant, McLouth Steel Corporation, of a high-speed, modern 4-stand tandem cold mill. Entry coil conveyor as well as the delivery coil conveyor to the annealing building is at floor level. Two single-stand skin-pass mills also have the entry and delivery conveyors at floor level. This is one of several features which make for greater safety and more efficient handling.

POLLAK

This merchant mill at The Pollak Steel Company, Marion, Ohio Works, is arranged for automated control and full repeating . . . employing automatic snip shears to prepare the bars for repeating.

USS FAIRLESS

This rugged, 2-high reversing blooming-slabbing mill designed entirely by CONTINENTAL is giving excellent performance . . . satisfying the particular requirements of United States Steel's Fairless Works. The mill was manufactured complete at CONTINENTAL's Wheeling Works, West Virginia. Rigid CONTINENTAL design pays off here, as it will in your plant, in smooth operation and continuity of production.

we serve...

there's nothing better than CONTINENTAL

You know the reputation of these famous metal producers for high-quality products. You know that to maintain that reputation, they must use nothing less than the best rolling mill equipment. All these companies depend, in some important way, on the performance and reliability of CONTINENTAL rolling mills and auxiliaries.

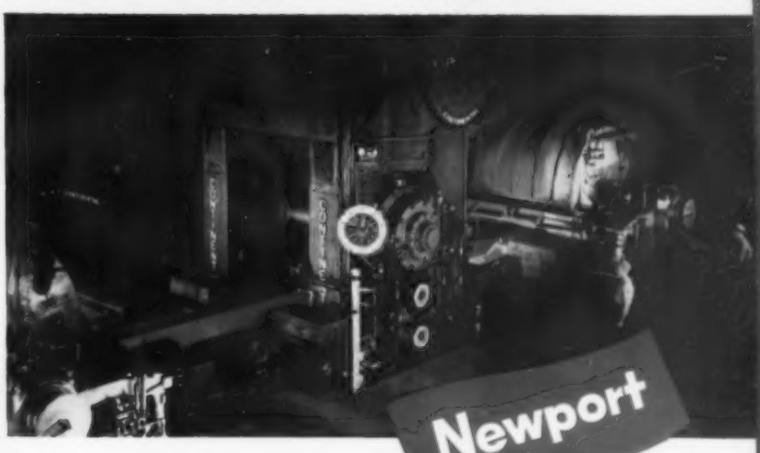
They find CONTINENTAL mill equipment *carefully* designed, *ruggedly* built, and *efficiently* installed. They find that CONTINENTAL's complete engineering supervision—from preliminary design stages to final satisfactory operation—helps them get equipment designed the way they want it, operating the way they want it, and in the shortest possible time.

CONTINENTAL is ready to serve *you* equally well. Your installation will be custom designed to fit your particular operating problems . . . will be built and installed by a company with 25 years of experience on *all types* of rolling mill equipment.

If your plans for future expansion include new rolling mill equipment or repairs to old, we'll be glad to discuss them with you.

This wide, continuous hot strip mill at the Gary Sheet and Tin Mill of United States Steel Corporation is well-known throughout the industry for its excellent tonnage performance and quality.

This Alcoa mill produces tapered aluminum sheet and plate. It can produce tapered sheet in unprecedented lengths required for big modern aircraft. It puts a continuous, *uniform* taper in the sheet from end to end. It was built by CONTINENTAL to meet Alcoa's specifications.



Newport Steel Corporation, Newport, Kentucky, uses this CONTINENTAL four-high reversing hot strip mill to roll precision-gage hot strip directly from ingots, on carbon as well as special grades of steel.

CONTINENTAL

CONTINENTAL
Foundry & Machine
Company

Engineering and Sales Office, 220 Grant St., Pittsburgh 19, Pa.
General Offices, 144 Railroad St., East Chicago, Ind.
Plants at East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division, Erie, Pa.

20-ton Bedford crane in extra severe duty mill type service

The crane illustrated is a 20-ton 75-foot span mill type bucket crane built to A.I.S.E. specifications and is used in the slag crushing plant of a large eastern steel mill.

The hoisting and holding motions have a speed of 75 fpm using two 100 hp motors operating a 3 cu. yd. 4-line bucket. Trolley speed is 175 fpm using two 19 hp motors and bridge speed is 280 fpm using one 100 hp motor.

All motors are mill type 600 series D. C. with 60-minute rating.

The 4 end trucks are of the 2-wheel compensating truck type with Tool Steel Process wheels.

Tool Steel Process gears and pinions are used throughout. All gear cases are of the fabricated-welded type utilizing oil bath lubrication.

Motor couplings are flexible type —all other couplings are forged steel flange type. Anti-friction bearings are used throughout.

The control cab has safety glass windows provided with sliding steel shutters and the cab floor is insulated to protect the operator from high temperatures in the pit.

Write for complete catalog

STEEL MILL CRANES BEDFORD

New York Office: 30 Church St., Room 426
New York 7, N. Y., Phone COrtlandt 7-1896
Pittsburgh Office: Oliver Building, Room 1141
Phone ATlantic 1-0136

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

Here's the Most Famous Industrial Heating Element Marketed Today . . .

The

Lee Wilson

"O" Tube

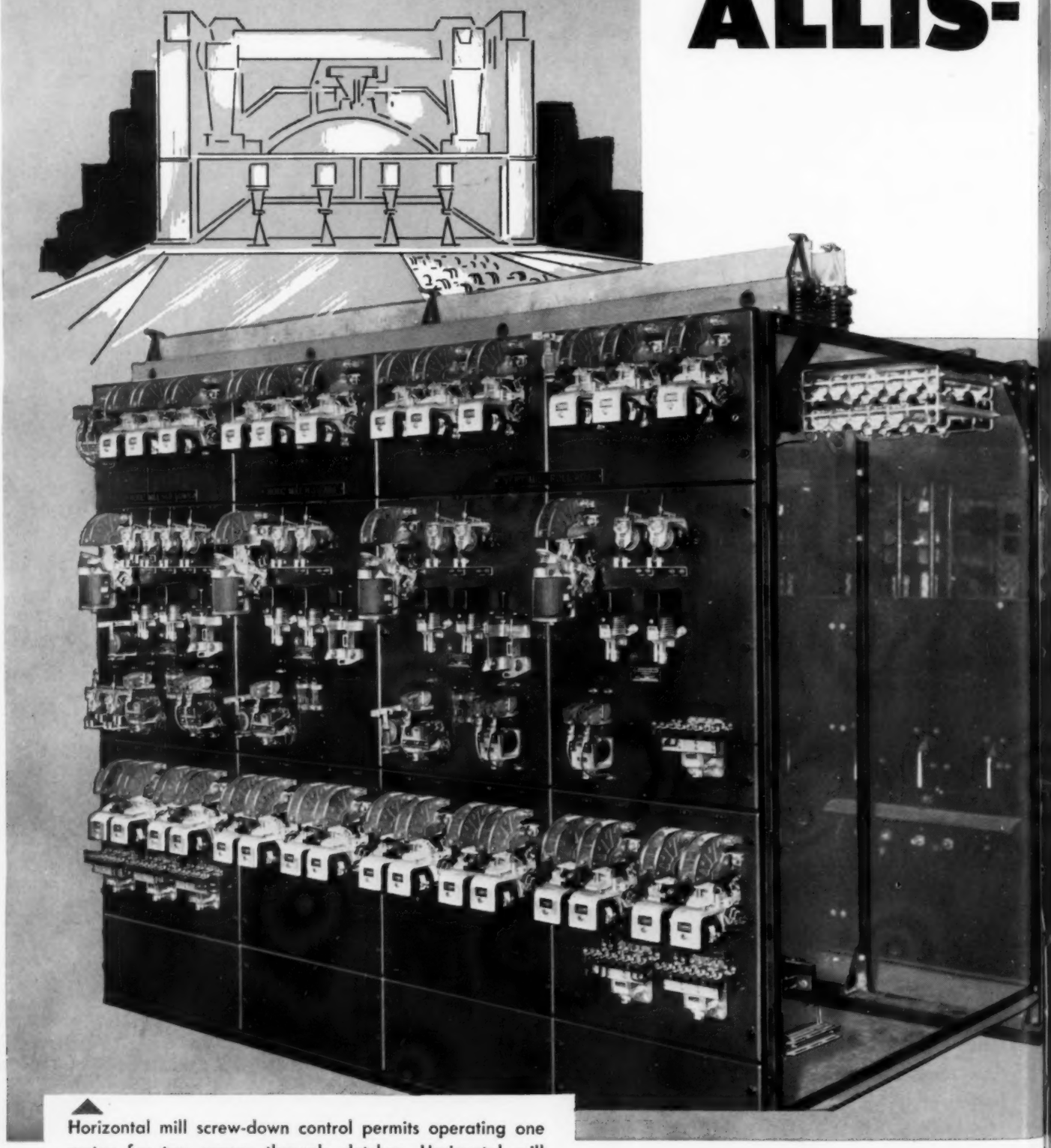
More metal tonnage is annealed by radiant tubes than by any other method, and the most efficient radiant tube is the popular Lee Wilson "O" Tube.

Designed by the company that pioneered radiant tube annealing, the "O" Tube has no equal when it comes to speed, control and useful life. Its development was responsible to a great degree for making the Lee Wilson Single-Stack the fastest selling sheet and strip annealing furnace on the market today.

LEE WILSON ENGINEERING COMPANY, INC. • 20005 West Lake Road, Cleveland 16, Ohio

STEEL MILL AUXILIARY CONTROL

Engineered ALLIS-



Horizontal mill screw-down control permits operating one motor for two screws through clutches. Horizontal mill housing adjustment panel is a reversible dynamic braking controller. Vertical mill roll adjustment panels permit operating two motors in unison or individually.

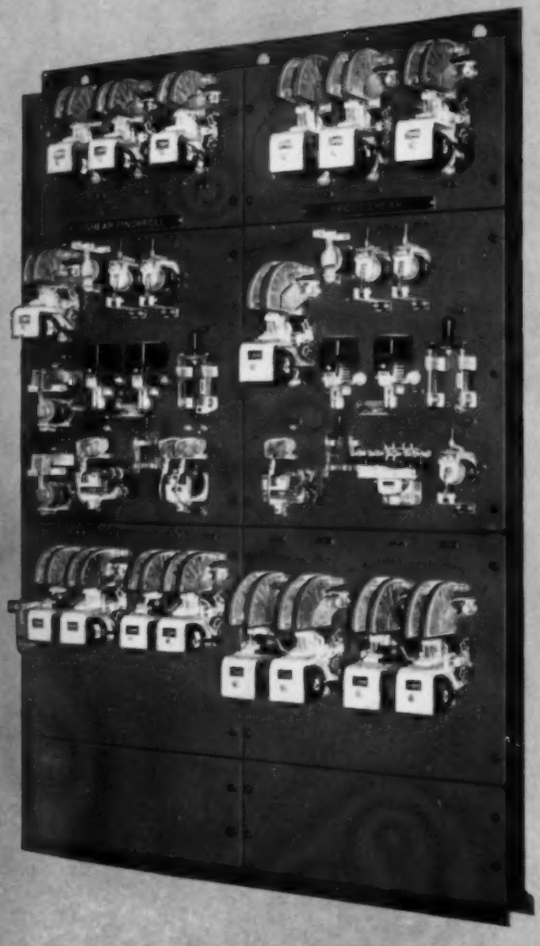
ALLIS-

and Built by CHALMERS

INSTALLED in some of the nation's largest mills, these Allis-Chalmers mill auxiliary controls are providing smooth, precision performance . . . affording maximum production with a minimum of outage time and maintenance.

When you modernize or expand, take advantage of Allis-Chalmers experience and engineering skill in building steel mill control. For further information see your Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wis.

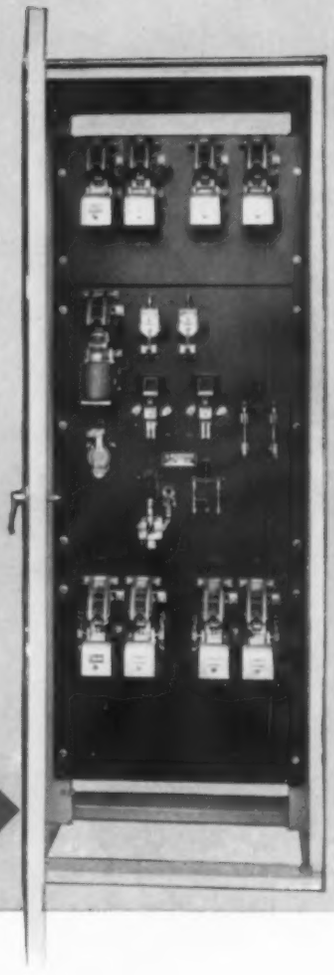
A-4744



▲ Motor control for hydraulic feed pumps. Non-reversible with field accelerating and field decelerating relays.

◀ Two reversible controllers with dynamic braking and series brake for an upcut shear and shear pinch roll.

▶ Reversible dynamic braking controller for roll conveyor. Operates at two speeds in either direction.



A-C ALLIS-CHALMERS

CHALMERS

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SITUATIONS WANTED

by strong, sturdy JOHNSTON CINDER POTS—

looking for opportunities to cut

slag-handling costs.

SPECIAL QUALIFICATIONS—Corrugated walls to increase radiating surface and cooling speed • curved sidewalls to prevent cracking and inward creep • bottom support brackets to relieve strain at critical sections • expansible rims to resist distortion.

FAMILY HISTORY—in actual use for over a quarter of a century with a reputation for constant efficiency, economical upkeep and long life.

BEST REFERENCES—from most of today's prominent plants in the ferrous and non-ferrous industries. Prefer being placed side by side with other cinder pots in your slag train for comparison of performance and service. Will operate effectively 24 hours a day on any slag train at blast furnace, open hearth or electric furnace. Available for immediate duty.

WANTED

s of industrial equip
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Minimum o
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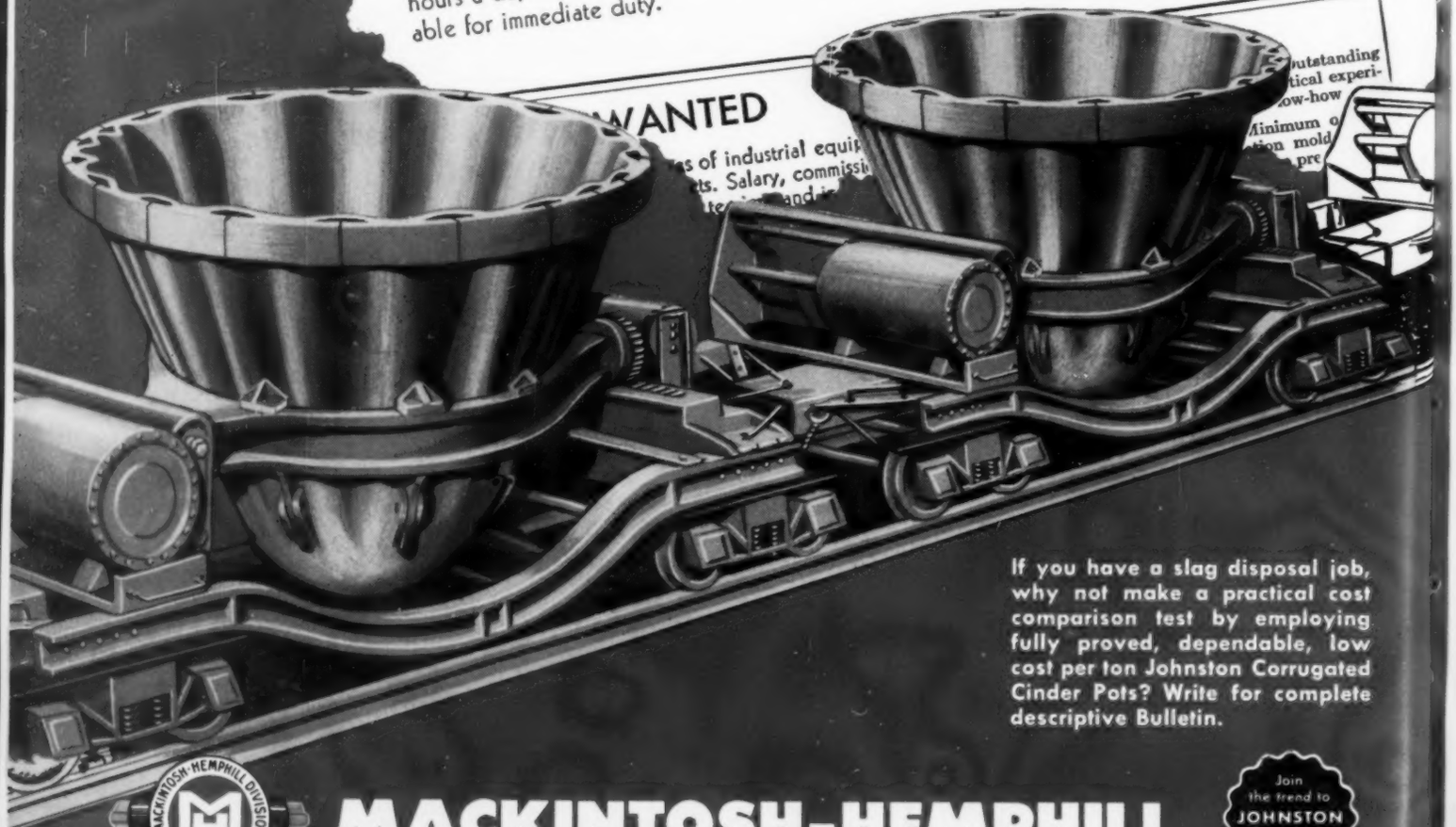

If you have a slag disposal job, why not make a practical cost comparison test by employing fully proved, dependable, low cost per ton Johnston Corrugated Cinder Pots? Write for complete descriptive Bulletin.

MACKINTOSH-HEMPHILL DIVISION
PITTSBURGH-U.S.A.
BLISS

MACKINTOSH-HEMPHILL

DIVISION OF E. W. BLISS COMPANY

Makers of the rolls with the striped sod wobblers

PITTSBURGH AND MIDLAND, PA.

Join the trend to JOHNSTON CINDER POTS

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: all types of cast mill rolls . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . Mackintosh-Hemphill rotary straighteners . . . electronically controlled contouring lathes . . . screw feed roll turning lathes . . . heavy duty engine lathes . . . shears . . . end-thrust bearings . . . steel and special alloy castings . . . reversing hot strip mills . . . Y-type cold strip mills.

Stearns circular lifting magnet carrying a 4,000-lb tank track.

How deep-ribbed cases protect

DEEP-DOWN
PULLING POWER

The cooler the magnet, the better its lifting efficiency. That's why powerful, deep-field Stearns lifting magnets are designed for maximum heat dissipation. In both the welded and bolted units, the heavily ribbed magnet case provides greater radiation area, for cooler and more efficient operation.

This design also provides greater protection against internal and external damage in the event of rough handling. These are important reasons why you can operate Stearns magnets profitably on steady, long-shift duty.

In addition to fast heat dissipation, Stearns magnets offer the following advantages:

- **Permanently sealed magnet coil not disturbed when servicing terminals or pole shoes.**
- **Leads and terminals fully protected against abrasion and shock.**
- **Vacuum-impregnated windings assure long life, and dependable operation.**
- **Waterproof construction.**

Stearns lifting magnets — both circular and rectangular are available in a wide range of standard sizes. Custom-built models on request. See your Stearns representative or write for Bulletin 35-B-2.

1092

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

STEARNS MAGNETIC, INC. **681 S. 28th St., Milwaukee 46, Wis.**

Instruments for Productive Maintenance

NEW G-E RECORDER, designated Type CH, has two modern styles in switchboard cases, in addition to the portable shown in operation above. Checking the efficiency of a lathe is just one of many applications of this new, versatile general purpose instrument.

REVOLUTIONARY WRITING SYSTEM ELIMINATES

New G-E Recorder Makes Clear Records Accurate and Easy to Read

NEW PLASTIC INKWELL holds full 3 ounces or triple amount of open kind. Comes sealed ready for insertion. You waste no time—spill no ink. After use—throw it away.

STURDY CONSTRUCTION of inking system combines fine writing qualities with extra long life. A highly polished, special alloy pen point reduces wear to a minimum.

GENERAL ELECTRIC ANNOUNCES . . .

NEW General Purpose Recorder

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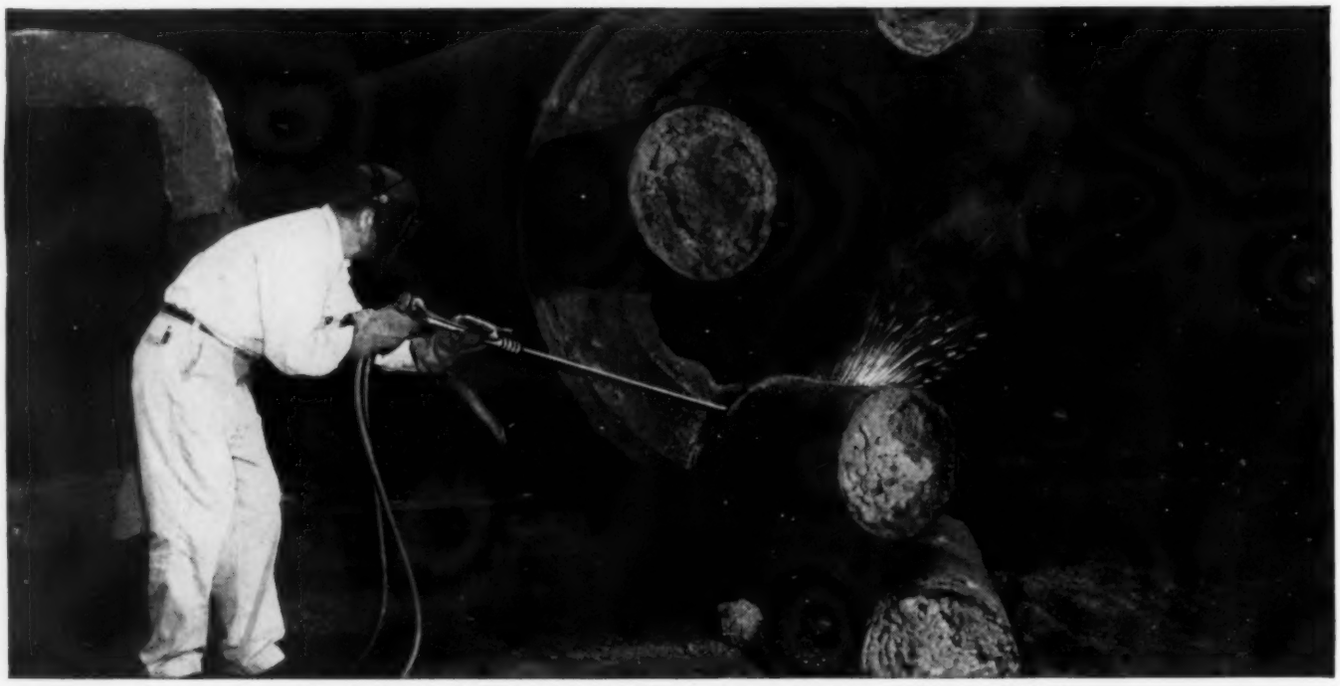

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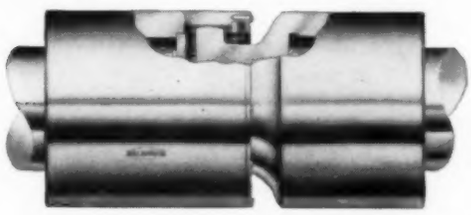

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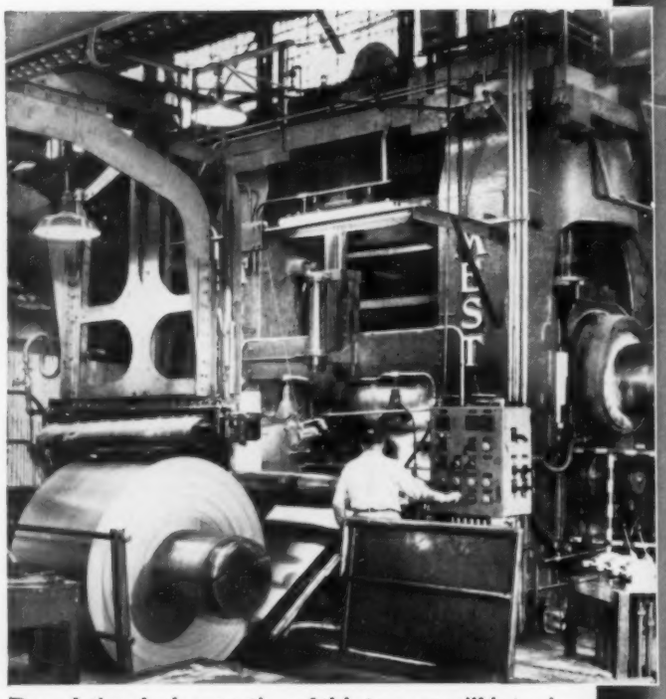
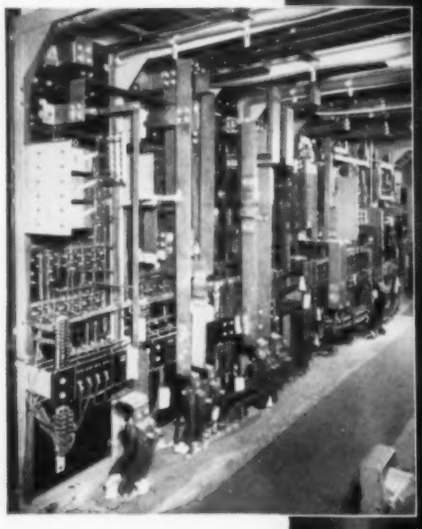


Round-the-clock operation of this temper mill is typical of the severe conditions that have proved Okolite-Okoprene's dependability in industrial service.



This interior view of the motor room shows the control panels for the temper mill, wired for dependability with Okolite-Okoprene.

Operating schedules on the 77-inch Temper Mill at Jones & Laughlin's Cleveland plant call for 20 turns a week of eight hours each—160 hours per week—and the schedule is kept. As in so many other steel plant installations where loss of production due to equipment failure is a serious factor, Jones & Laughlin here relies on Okolite-Okoprene to eliminate electrical outages.

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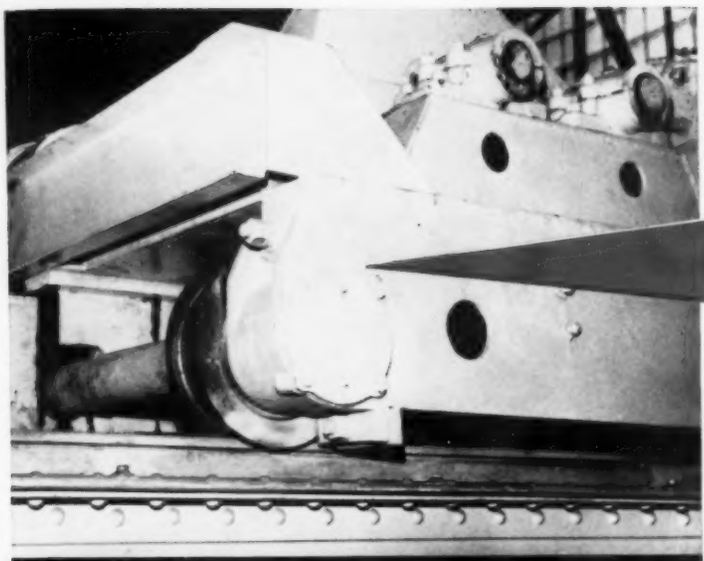

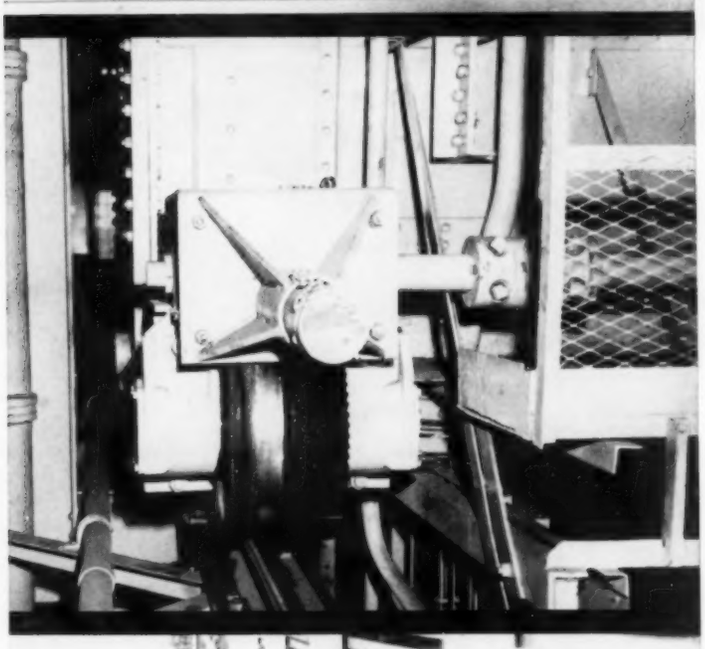

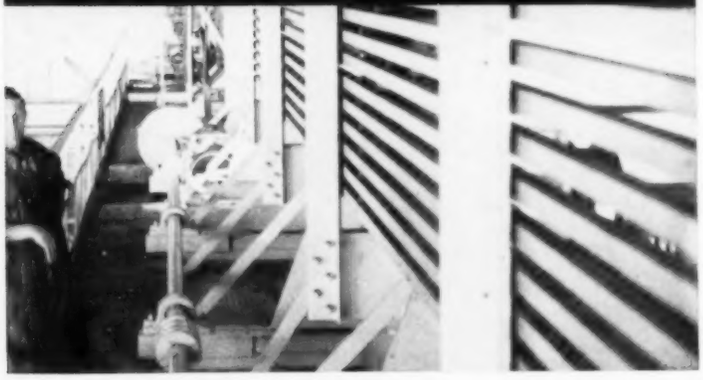

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Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period March 29, 1955 through April 19, 1955 . . . .

TAP HOLE DRILL GUIDE

▲ U.S. 2,705,630, issued April 5, 1955 to William Taddeo and assigned to Bethlehem Steel Co., describes a device for positioning a drill in front of a blast furnace tap hole, so as to preserve a predetermined and consistent location, length, and angle of tap hole drilling.

The device is shown in Figures 1 and 2. A conventional blast furnace 1 is shown as provided with the usual tap hole 2, opening onto a trough or runner 3 for the flow of hot metal upon tapping, and normally kept stoppered by a clay plug 4. Welded to the furnace outer metal structure 5 above the taphole 2 is a bracket 6. Vertical filler plates 8 are bolted to this, as well as a vertical support plate 9 having a center section 10 and side flanges 11. The flanges 11 have vertically elongated bolt holes 12 which, by means of through bolts 13, will permit an adequate range of vertical adjustment of the support plate 9. The support plate 9 may also be moved in or out with relation to the furnace simply by removing or inserting additional filler plates 8, and is then bolted permanently in proper alinement with the tap hole 2. Welded to the outer face of the support plate are two pins 16 and 17. The upper pin 16 is fairly long and has two spaced vertical slots 18 and 19. The lower pin 17 is shorter, and has only one slot 20.

The drill guide 21 proper consists of a channel-shaped member 22, having holes to receive the pins 16 and

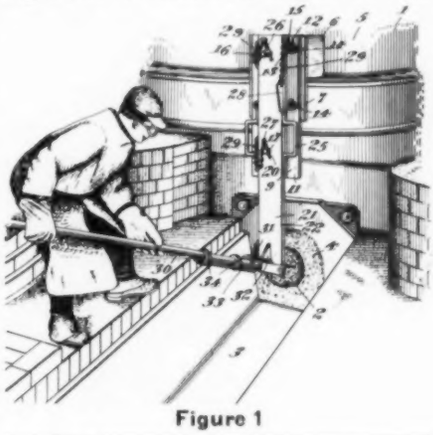


Figure 1

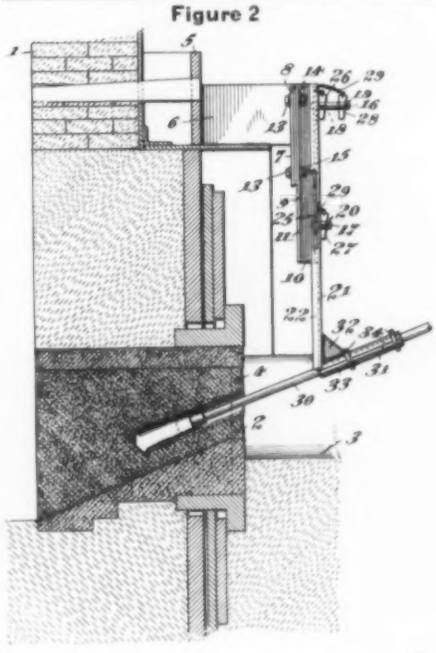
17, and fitting over the center section 10 of the support plate 9. Rod handles 25 welded on each side of the guide 21 are provided for convenience, and tapered keys 26, 27, 28 adapted to be inserted in the pin slots 18, 19 or 20 are attached by chains so that they will not be lost or misplaced when the guide is removed.

In order to guide the drill 30 at the proper angle of inclination (shown for example as 22 degrees 30 minutes from horizontal), a half-section of pipe 31 open at the bottom is welded to the triangular web plate 32 and the bottom of the channel member 22.

The guide lock is a counterpart half-section of pipe 33 with a pair of rings 34 welded on it. After the drill bit 30 is passed through the rings 34, it is a very simple matter to manipulate the drill so that the rings 34 will hold the counterpart half-sections of pipe 31 and 33 together and then to start drilling as in Figure 1.

As a safety feature, the workman may at any time withdraw the drill and swing the guide 21 to right or left to determine how much further he can drill without drilling completely through the clay plug 4. This is accomplished by removing the

Figure 2



keys 26 and 27 from their normal position in the inner pin slots 18 and 20, and inserting the key 28 in the outer slot 19 of the long top pin 16. The guide 21 may then be pulled away from the support plate 9 and off the bottom pin 17, and will be pivoted on the top pin 16.

When the drill has reached the desired depth in the taphole, the drill and guide will be removed entirely, and the opening will then be completed with an oxygen lance.

BLAST FURNACE TUYERE

U. S. 2,705,000, issued March 29, 1955 to Selwynne P. Kinney and assigned to S. P. Kinney Engineers, Inc., describes a blast furnace tuyere

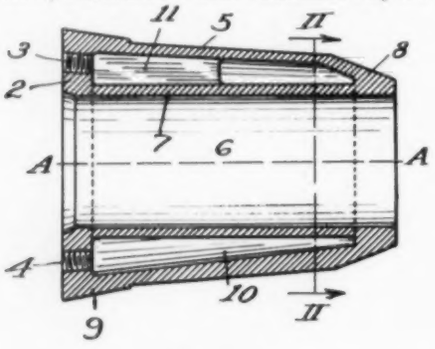


Figure 3

which is claimed to give a longer life in service, without change in the outer dimensions of the tuyere, and with very little added cost.

As shown in Figures 3 and 4, the outer wall of the tuyere is circular in section, but the inner surface of this wall defines in the lower half of the tuyere, an arc which is eccentric to

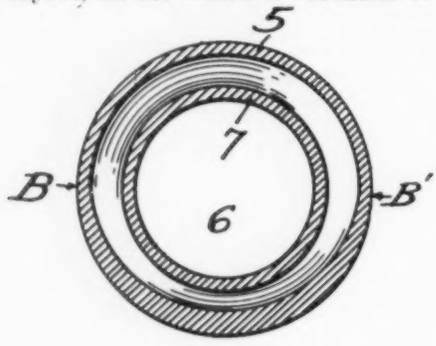


Figure 4

the outside, so that the wall under the nose is thicker than the top wall. Toward the back end of the tuyere, the two circles become fully concentric, so that this thicker portion tapers gradually to the normal wall thickness.

This not only provides protection back of the nose against undercutting by hot metal, but it also gives a water-circulating space where the water has a non-uniform velocity with the greatest velocity over this thickened part giving an especially effective "scouring" action to this very vulnerable point to carry away the heat, and also retard sedimentation which otherwise tends to occur to a considerable extent at this point.

METHOD OF REMOVING SULPHUR FROM PIG IRON

In U.S. 2,706,152, issued April 12, 1955 to Gerhard Derge and Kenneth M. Goldman, and assigned to Carnegie Institute of Technology, sulphur is removed from molten pig iron as it leaves the blast furnace.

Aluminum wire or shot is added to the molten pig iron in the refractory trough between the tap hole and the skimmer, at which point it is covered by a layer of blast furnace slag. As the slag rises to the surface of the metal, a marked migration of the sulphur from the metal into the slag results. The inventors claim that a pig iron of unexpectedly low sulphur concentration is obtained, but no data is given.

DEOXIDATION OF MOLTEN IRON OR STEEL

U.S. 2,705,196, issued March 29, 1955 to Franz Wever and Walter Koch, and assigned to Manufacturers Chemical Corp., describes a method for thoroughly deoxidizing iron or steel.

The iron or steel is first deoxidized in the conventional way with a deoxidizing element having moderate affinity for oxygen (such as manganese or silicon), and then is deoxidized further with an element of greater affinity for oxygen (such as aluminum or calcium). The second deoxidant is added only after the liquid oxides formed in the first deoxidation have had time to be removed from the molten iron or steel in the ladle. The second deoxidant is introduced in a form which prevents premature oxidation, that is, within protective iron containers.

For example, 50,000 kg of molten steel in the ladle were first deoxidized by introducing 500 kg of manganese and 200 kg of silicon into the ladle. The molten metal was then allowed to stand for 10 minutes to allow the molten products formed to rise into the slag. Further deoxidation was then carried out by the addition of 25 kg of aluminum in a closed iron cylinder about 3 meters long, 2 in. in diameter, and 5 mm in wall thickness. Melting of the container took place in 1 to 2 minutes, after which deoxidation occurred.

The advantage of using this process over adding aluminum directly into the bath in the first place is that that would result in a great deal of inclusions of solid oxides, whereas that is minimized in the present case. The aluminum oxide is refractory, while the other oxides are not.

BURNER PORT LINING FOR SOAKING PIT

U.S. 2,705,138, issued March 29, 1955 to Frank J. Pikus and assigned to United States Steel Corp., describes an improved gas port structure for bottom fired ingot soaking pits.

In Figure 5, numeral 2 designates a bottom fired ingot soaking pit having a refractory brick bottom 4, a center burner port 6 and a hearth 8 consisting of loose granular material such as coke breeze.

The burner port lining 10 consists of a steel bottom plate 12 having a center hole 14 through it, and a brickwork construction 16 projecting upward from the bottom plate to a point above the level of the hearth 8. The center of the brickwork 16 consists of a filling of cast iron 18. The top 20 and the outer periphery of the brickwork are covered with a layer 24 of plastic refractory, such as plastic chrome.

The lining is fabricated outside of the soaking pit by laying chrome-magnesite brick on the steel plate 12 to form two vertical walls 26 around the hole 14 with a space 28 between the walls. The space 28 is then filled with the molten cast iron 18.

Lifting eyes may be attached to the portion of the steel plate 12 immediately surrounding the hole 14. After the molten cast iron 18 has solidified in the space 28, the lining 10 is lifted by attaching the lift cables of an overhead crane to the eyes, and is deposited on the bottom of the soaking pit with the hole 14 alined with the burner port 6. After the

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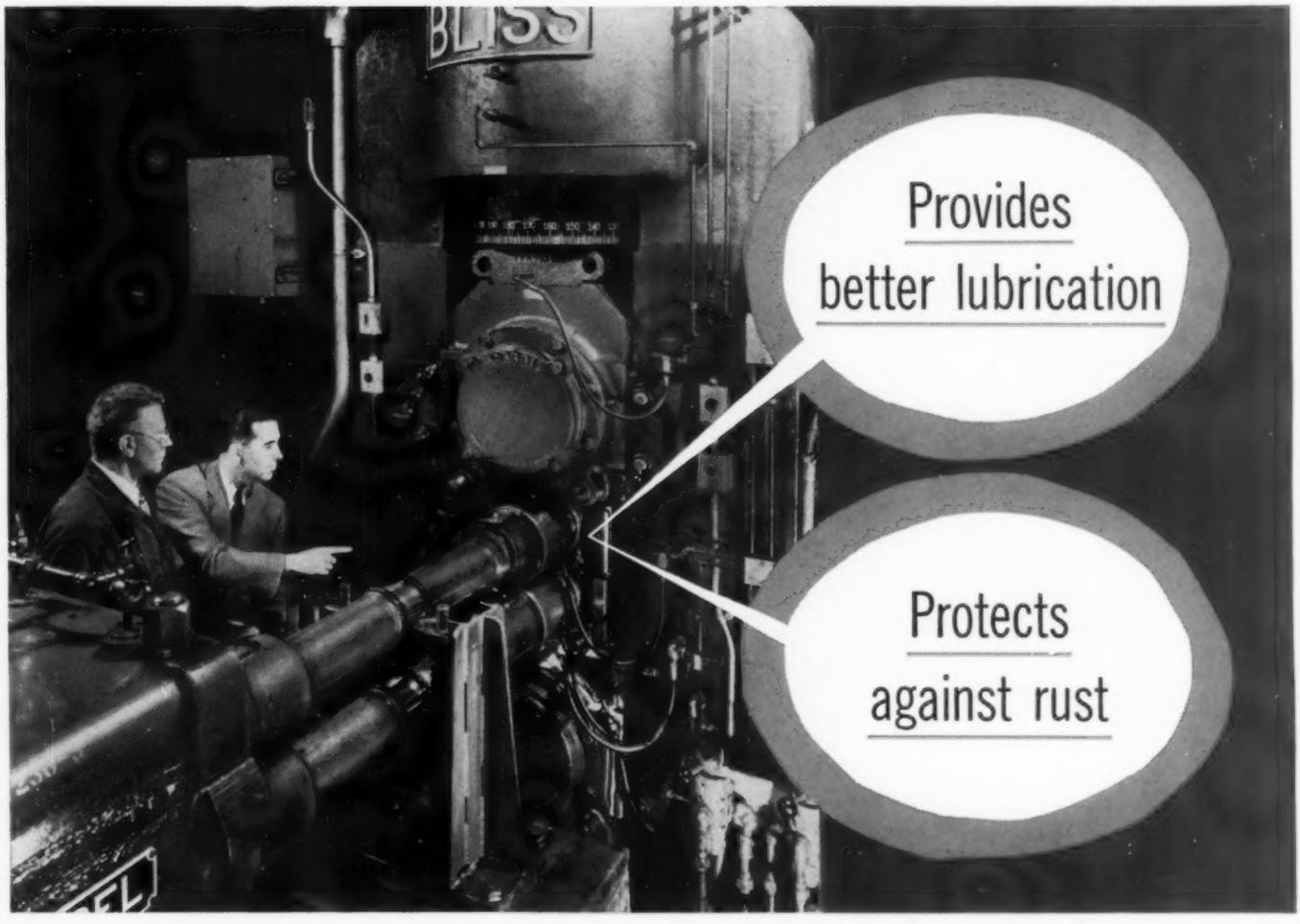

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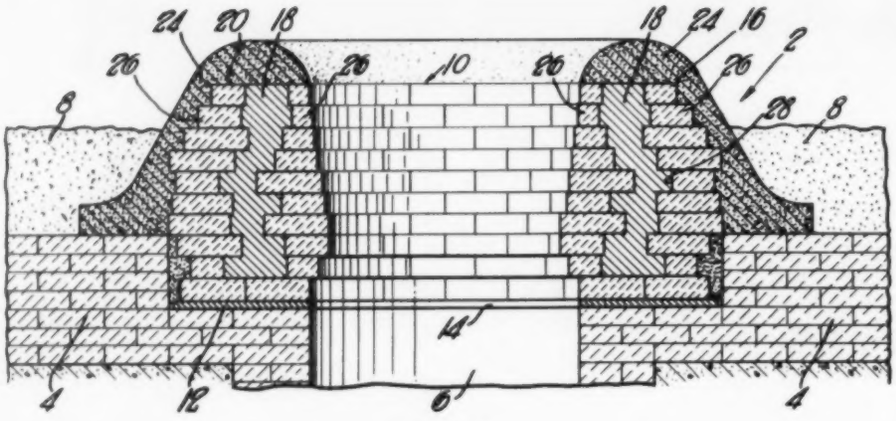

Figure 5

lining has been positioned in the soaking pit, the portion of the bottom plate 12 surrounding the hole 14 on which the lifting eyes are fixed is burned off with a cutting torch. This enlarges the diameter of the hole 14 so that it is substantially equal to the diameter of the burner port 6. As a final operation, a layer of plastic-chrome material is applied to the top 20 and outer periphery 22 of the brickwork 16.

METALLURGICAL HEATING FURNACE

U.S. 2,706,110, issued April 12, 1955 to Harold J. Ness and assigned to Metallurgical Processes Co., describes a direct-fired furnace for heating steel preparatory to hot working or for soaking. The main object of the invention is to avoid decarborization and oxidation of the metal.

The principal features of the furnace described are the provision of a protective atmosphere containing a small amount of lithium vapor, and means for maintaining this atmosphere at higher temperatures than were previously possible. The amount of lithium required has also been reduced to $\frac{1}{20}$ to $\frac{1}{50}$ the amount required by the inventor in an earlier patent, U.S. 2,181,093, granted Nov. 21, 1939.

DEOXIDIZING A HEAT OF STEEL

U.S. 2,705,673, issued April 5, 1955 to James Fernando Jordan, describes a method of deoxidizing a heat of steel in an electric furnace preparatory to casting. Basic electric processes normally yield a steel which exhibits poor fluidity in the molten state but excellent physical properties once it has solidified, while acid electric processes have a fluidity which varies from poor to excellent and physical properties which vary from poor to fair. According to the inventor, his method provides uniform results regardless of whether acidic or basic conditions are employed.

The method is based on what the inventor calls "the balanced condition" between the oxidizing effect of the oxygen content of the metal on the one hand and the net deoxidizing effect of the deoxidizers present in the molten metal on the other hand. "Balanced conditions" are maintained between deoxidation and casting.

Briefly, the process involves adjusting the temperature of the bath, adding enough oxygen to the bath to develop a CO boil (either by oxygen lance or by the addition of iron oxide), shutting off the power, adding an excess of deoxidizers, and tapping the heat.

APPARATUS FOR AUTOMATICALLY ASSORTING ANGLE-IRONS TO LENGTH

U. S. 2,705,072, issued March 29, 1955 to James W. Calvin and assigned to United States Steel Corp., provides an apparatus for automatically assorting angle-irons to length.

As shown in Figures 6 and 7, the device includes a support frame 2 which can conveniently be constructed of channel side rails 4 and 5, channel legs 6 and transverse spacers 8. A shaft 10 journaled in pillow-blocks 12 is mounted at the left end of this frame and carries a pair of spaced sprockets 14. A similar pair of sprockets 16 is provided at the right end of the frame. These are mounted on shaft 18 journaled in bearings 20 in take-up frames 22. The sprockets engage chains 24 which are interconnected by a series of transverse rods 26 spaced at intervals along the chains to form angle-carrier elements. Each of the rods 26 is provided with a stop-collar 28 and a stabilizing-block 30. The major mass of block 30 is in effect a counterweight which hangs below its support rod at all times, and provides a stable seat for an angle during movement of the

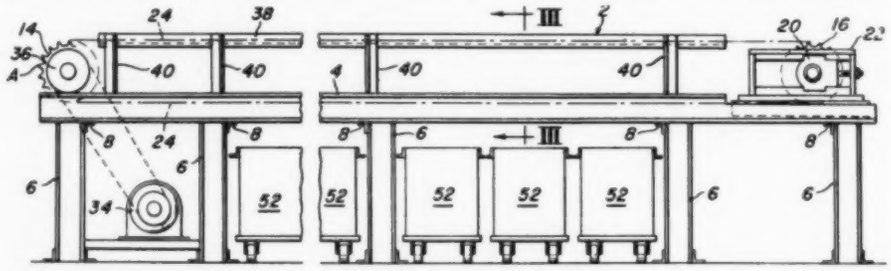

Figure 6

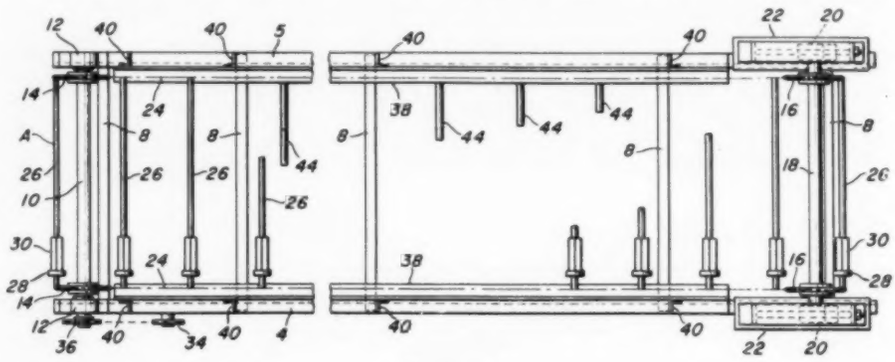

Figure 7

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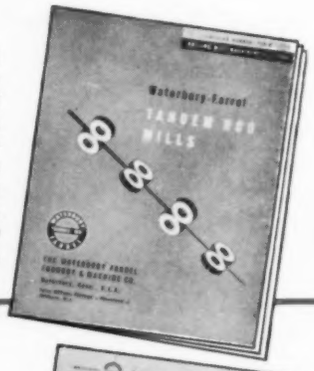
Cir. No. 915-N-2

Detailed information on 2 sizes of presses for mass production blanking, piercing, shallow drawing and forming. Speed range 300 to 900 rpm. Shows machines from several angles, gives close-ups of design details and pictures typical work samples. Complete specifications included. 8 pages.

TANDEM ROD MILLS—

Cir. No. 729-R

8-pager on mills for high speed reduction of non-ferrous and ferrous rod. Shows various sizes of mills plus work samples and a cross-sectional reduction sequence. Tells how mill can reduce operating costs. Also discusses pay off unit, straighteners, coilers and cooling method. Table gives capacities and other data.



MULTIPLE PLUNGER PILLAR PRESSES—

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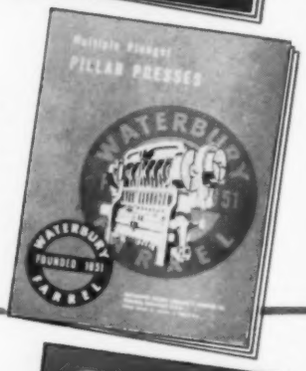
8-page illustrated booklet presents latest features in WF multiple station pillar presses. Gives specifications and capacities for six sizes. Shows typical work samples and also covers accessory equipment.



2-HI ROLLING MILLS—

Bul. No. 111-R

Gives general information on wide variety of 2-Hi mills for cold or hot rolling. Rolls range from 5" dia. to 24" dia. Pictures five different sizes.

INCLINED, SHELL THREAD ROLLING MACHINE—

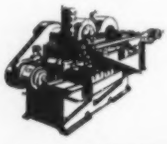
Cir. No. 833-EL-2

Describes and illustrates automatic inclined shell threader for attachment to eyelet machine or with independent feed. Covers use, construction, operation and drive. Shows work samples and has table of specifications.

WIRE FLATTENING MILLS—

Bul. No. 110-R

Gives information on mills with production speeds approaching 3,000 FPM. Shows various sizes. Rolls range from 4" dia. to 12" dia. Includes data on edgers, pay-offs, winders, drives, coolant system, etc.



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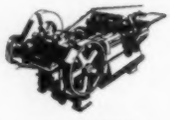
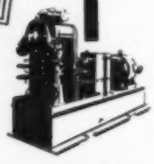


POWER PRESSES



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carrier-chains. A motor and gear reduction unit 34 is connected to the shaft 10 through chains and sprockets 36 and arranged to drive the sprocket 14 in a clock wise direction.

A pair of guide angles 38, carried by angle-posts 40, support the chains 24 during their travel toward the right end of the frame; a similar pair of angles attached to the inner faces of side rails 4 and 5 support the chains during their return to the forward end of the frame.

Spaced along the side rail 5 below the guide angle and adjustably supported are a number of kick-off bars 44. The bars 44 are round in section and of an off-set shape so that they may be rotated in their supports to adjust their clearance of the chain 24. The bars 44 increase in length in increments toward the forward end of the frame and extend into the path of travel of angles on the carrier-rods, so that the longest length of angle is discharged first and the shortest last. Storage bins 52 are provided below each of the bars to receive the sorted angles.

In using the apparatus, an angle is placed on each of the rods as they reach position A. The angle is placed over the stabilizing block and against the stop-collar. The angles so positioned are carried the full length of the machine on the top level and are kicked off into the appropriate storage bin by the bars 44 as the carrier chains return along the lower level. Discharge is accomplished when a kick-off bar catches the edge of an angle and tilts the angle and stabilizing block so that the angle slides off into the storage bin below.

PROCESS FOR CONVERTING BLACK IRON OXIDE TO RED IRON OXIDE

U. S. 2,705,188, issued March 29, 1955 to William A. Swaney and assigned to United States Steel Corp., describes a process for converting black iron oxide, made from waste pickle liquor, to red iron oxide suitable for pigments.

The process is shown in Figure 8. The apparatus consists of an agitator 10, a rotary kiln and an obsorption column 13. Black iron oxide is introduced in a dry state to the agitator from a storage hopper 14. Water is introduced to the top of the absorption column at 15. As the water passes through this column, it absorbs effluent sulphur trioxide and sulphur dioxide from the kiln. A pump 16 transfers water from the bottom of the absorption column to the top of the agitator via a pipe 17. Make-up sulphur trioxide is introduced to the agitator at 18, preferably as dilute sulphuric acid. The sulphur trioxide in the solution in the agitator is kept at such a low concentration that there is no apparent reaction with the iron oxide. The acid concentration in the agitator is 2 to 5 per cent H_2SO_4. The material discharged from the agitator is an easily handled slurry.

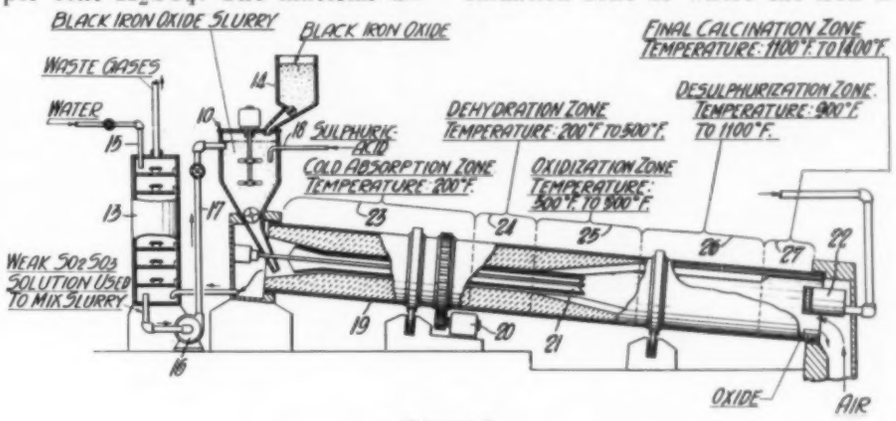
BLACK IRON OXIDE SLURRY
BLACK IRON OXIDE
FINAL CALCINATION ZONE TEMPERATURE: 1100°F. TO 1400°F.
WASTE GASES
WATER
DESULPHURIZATION ZONE TEMPERATURE: 900°F. TO 1100°F.
DEHYDRATION ZONE TEMPERATURE: 200°F. TO 500°F.
18 SULPHURIC ACID
COLD ABSORPTION ZONE TEMPERATURE: 200°F.
OXIDIZATION ZONE TEMPERATURE: 500°F. TO 900°F.
WEAK SO2 SO3 SOLUTION USED TO MIX SLURRY
OXIDE
AIR

Figure 8

The rotary kiln includes a cylindrical body 19, a drive motor 20, and a fixed scraper 21. A gas burner 22 is located at the discharge end of the kiln. The kiln has a series of zones of progressively increasing temperature. Starting at the feed end, these are a cold absorption zone 23, in which the temperature is less than 200 F, a dehydration zone 24, in which the temperature is in the range 200 to 500 F, an oxidation zone 25, in which the temperature is in the range 500 to 900 F, a desulphurization zone 26, in which the temperature is in the range 900 to 1100 F, and last a calcining zone 27, in which the temperature is in the range 1100 to 1400 F.

Slurry from the agitator feeds into the cold absorption zone 23 of the kiln, where it absorbs gaseous sulphur trioxide driven off the material farther along in the kiln. The sulphur trioxide thus absorbed plus the sulphuric acid already in the slurry reaches a sufficient concentration in spots that exothermic reaction takes place. Next the slurry passes to the dehydration zone 24 where the water is driven off, leaving a dry complex of sulphur and oxygen compounds of iron. Next the material passes to the oxidation zone 25 where the iron is oxidized to the ferric state by the action of heat and air. Next this material passes to the desulphurization zone 26, where the sulphur is driven off as sulphur trioxide, a small part of which dissociates to sulphur dioxide. Next the material passes to the calcination zone 27 where final calcination takes place. The red oxide which discharges from the calcination zone can be processed in any conventional way to form pigments.

The gaseous products of combustion and any of the sulphur bearing gases which escape absorption in the slurry in the cold absorption zone pass from the kiln into the absorption column 13. The input water absorbs the soluble gases which include the sulphur trioxide and the sulphur dioxide, and thus returns these gases to the system.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,704,883	3/29/55	Method of welding carbon steel to stainless steel	United States Steel Corp.
2,706,111	4/12/55	Metal melting furnace	Selas Corp. of America
2,706,340	4/19/55	Profile tracing machine	United States Steel Corp.
2,706,422	4/19/55	Method of cold reducing metal in strip form	The Cold Metal Products Co.
2,706,564	4/19/55	Drip pan for coke oven doors	United States Steel Corp.
2,706,625	4/19/55	Apparatus for continuously centering a moving strip	United States Steel Corp.
2,706,681	4/19/55	Alloy for addition to iron or steel	Vanadium Corp. of America
2,706,696	4/19/55	Age hardening austenitic steel	Crucible Steel Co. of America

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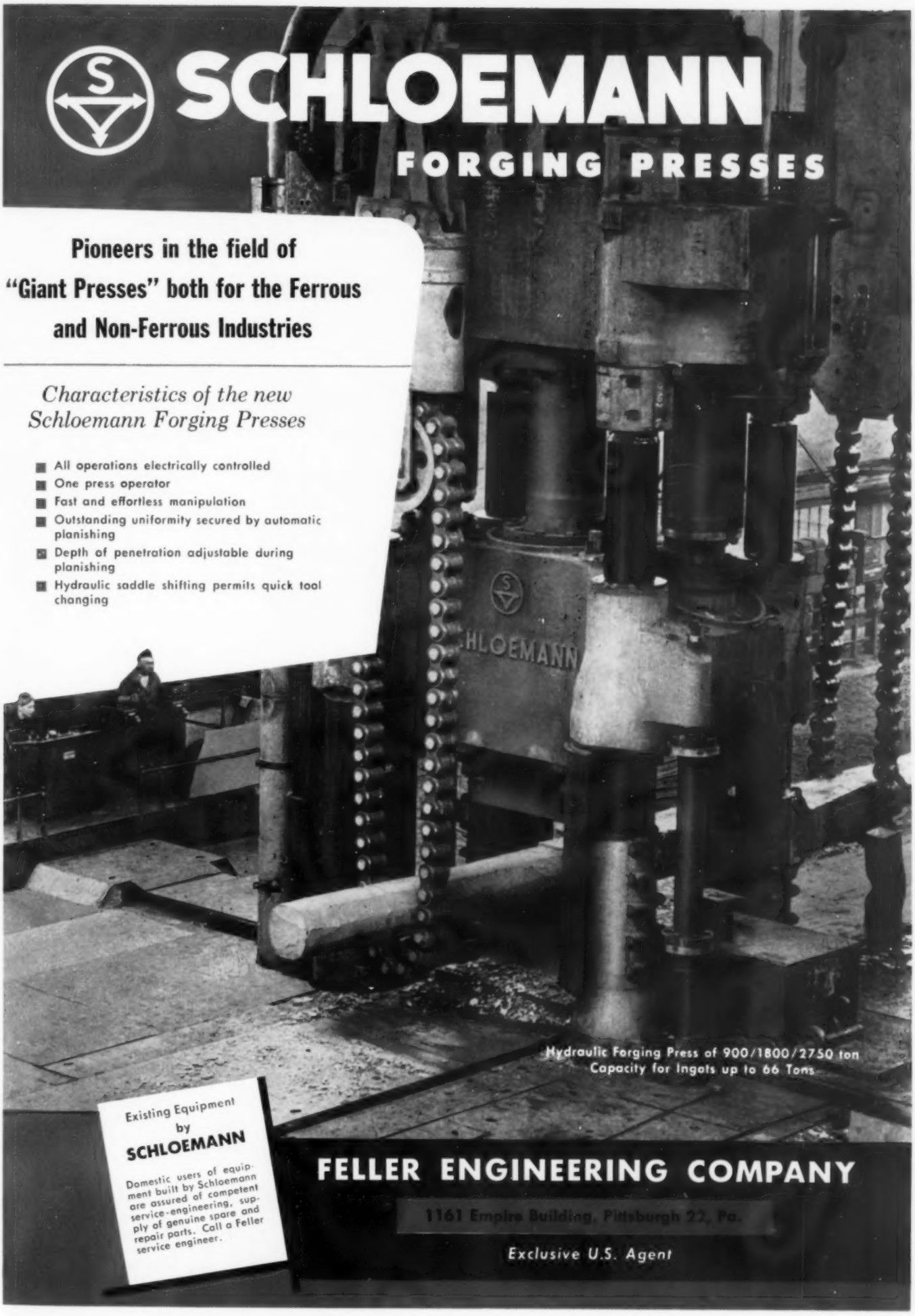

Hydraulic Forging Press of 900/1800/2750 ton Capacity for Ingots up to 66 Tons

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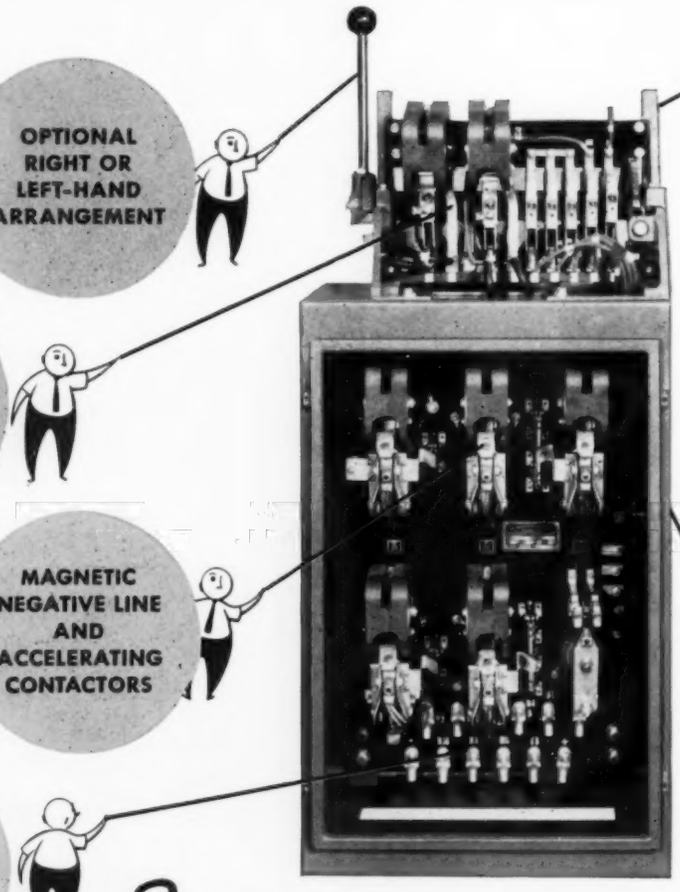
Combination Manual and Magnetic Controller for Cranes . . . Charging Machines . . . D-C Control Jobs



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New mill on TIMKEN® bearings tapers 10′ x 33′ aluminum sheets for aircraft wings

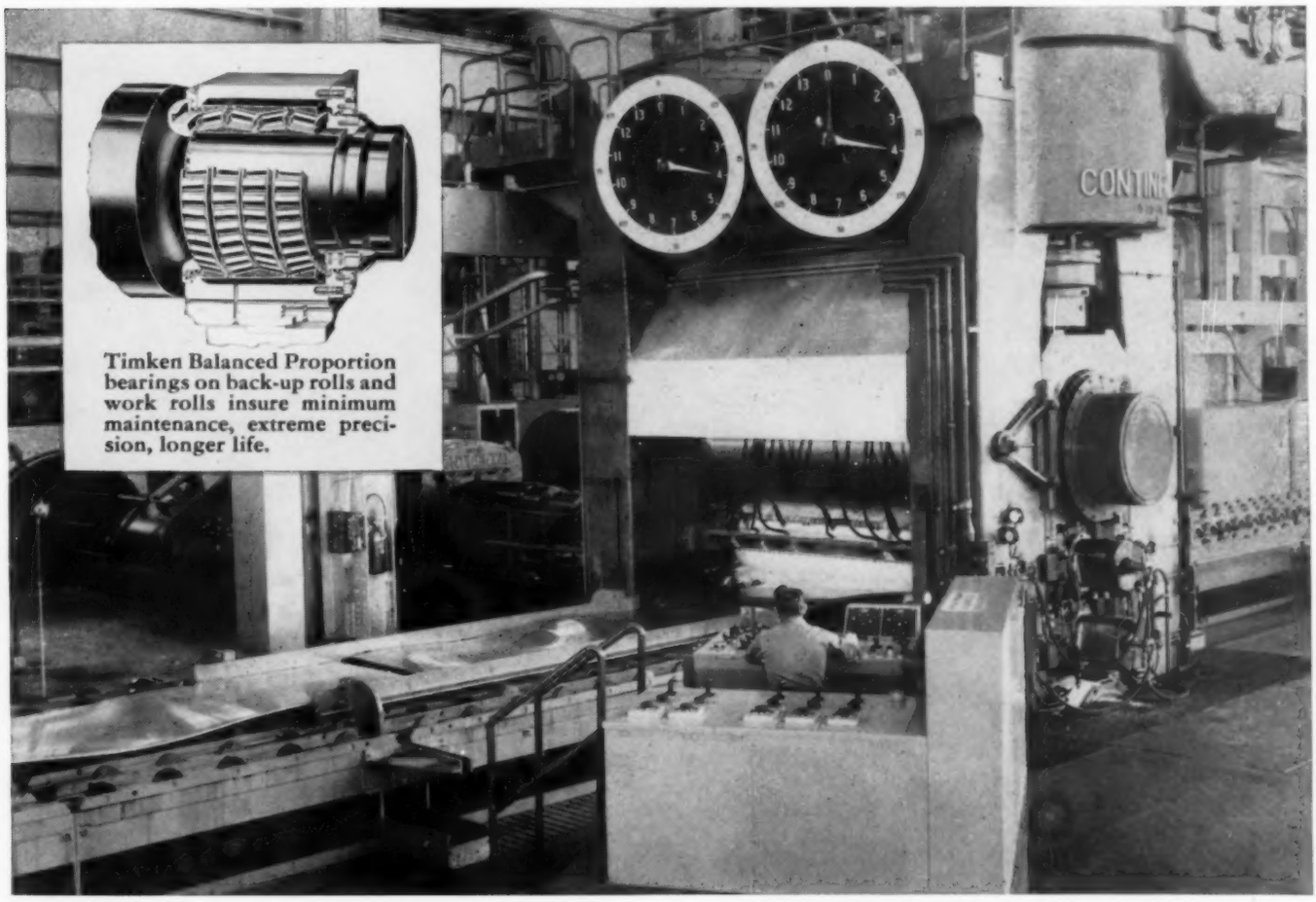
A 4-HIGH reversing mill, 23″ x 60″ x 144″, which tapers aluminum sheet and plate up to 10′ wide and 33′ long, is now in operation. This mill is used for the fabrication of tapered sheet and plate. Tapered sheet and plate products permit the fabrication of modern aircraft of increased speed and increased carrying capacity at no sacrifice in strength. Built by the Continental Foundry & Machine Company, this huge new rolling mill uses Timken® tapered roller bearings on back-up rolls, work rolls, screw-downs and breaker blocks.

Timken balanced proportion bearings give this mill the extreme precision required in such rolling operations. Timken balanced proportion bearings have load ratings up to 40% higher than the same-size bearings in older designs. In some mills, they increase bearing life expectancy almost three times. And the mill can be stopped and restarted without altering or relieving screwdown pressures.

Timken bearings, because they're tapered, take both radial and thrust loads in any combination. They practically eliminate friction because they're designed by geometrical law to have true rolling motion. And made with extreme accuracy to conform to their design.

Always specify Timken bearings in the equipment you build or buy. Look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

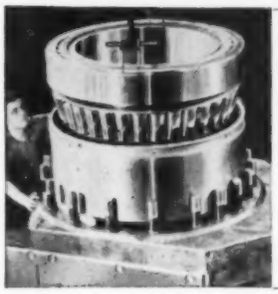


Timken Balanced Proportion bearings on back-up rolls and work rolls insure minimum maintenance, extreme precision, longer life.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

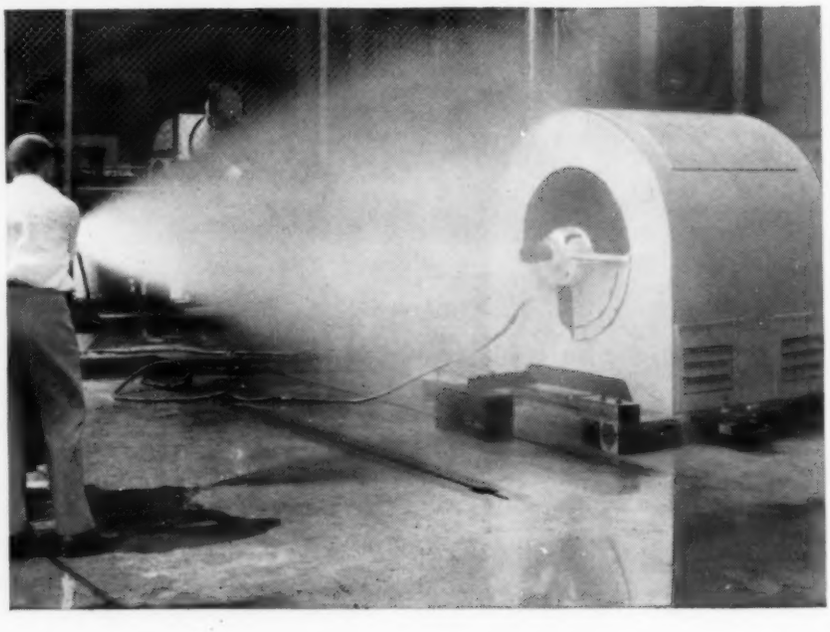


ROLL NECK BEARING ENGINEERING SERVICE

Our field and service engineers have had years of experience with problems of roll neck bearing design and operation. They'll help you select bearings and design mountings. Only Timken tapered roller bearings have these advantages: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. nickel-rich Timken alloy steels.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↓ AND THRUST →○← LOADS OR ANY COMBINATION

This 800-hp Westinghouse twin-motor drive operates the skin-pass mill work rolls in a 56″ tandem cold mill.



Tests like this prove Thermalastic's superiority. Water can be sprayed into the inlet openings while the motor is running. Immediately following, the coils successfully withstand three times the normal line-to-ground operating voltage.

"Out in the mill" operating conditions don't faze Westinghouse d-c motors

Dust, dirt, moisture, and similar mill atmospheres take a heavy toll of conventional d-c motors. That is why these motors are installed in a separate closed room, where possible. But, often, this is not the most desirable location from an operation standpoint. The best answer is to specify Westinghouse enclosed d-c motors... they are built to operate in most any contaminated atmosphere.

Thermalastic® insulation now available on large d-c motors

The same Thermalastic insulation that has proved its merit on large Westinghouse a-c motors is now being used on the full line of Westinghouse d-c motors above 250 hp. This is a mica insulation that has characteristics far superior to any ordinary insulation. An impregnating resin is used that is very stable chemically and has high moisture resistance. This, coupled with a high degree of fill achieved in the impregnating process, renders Thermalastic impervious to contamination from foreign elements.

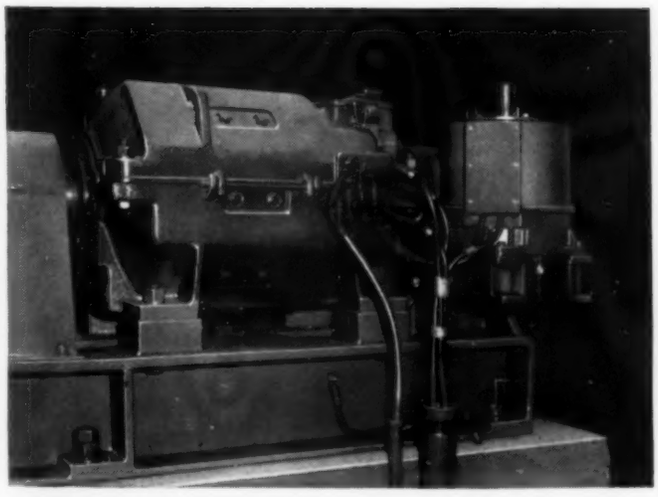
D-c mill motors now provide easy access to brushholders

Whenever you locate a d-c motor in a contaminated atmosphere, you step up the maintenance required on commutator and brushes. That's why the new Westinghouse mill motor is built so that both top and bottom brushholders are accessible through the top openings. Access openings have been added in the lower half of the frame, also.

Ask your Westinghouse Man With The Facts about all the many other plus advantages you get when you install Westinghouse steel mill drives and steel mill auxiliaries. MP-3042

YOU CAN BE **SURE**... IF IT'S

Westinghouse



This Westinghouse d-c mill motor with SA brake is driving a bar transfer machine in a bar mill. The motor is built to operate regardless of dust and dirt accumulation.

Remove the cover on any frame opening and you have ready access to the commutator and brushholder rigs. Brushholders are quickly removed by loosening the tap bolt.

PLATE HANDLING CRANES . . by "Shaw-Box"

You will find many mills handling their plates with "Shaw-Box" Cranes. Plate handling cranes have long been another specialty in the various types of cranes that make up the well-rounded "Shaw-Box" Line of Cranes.

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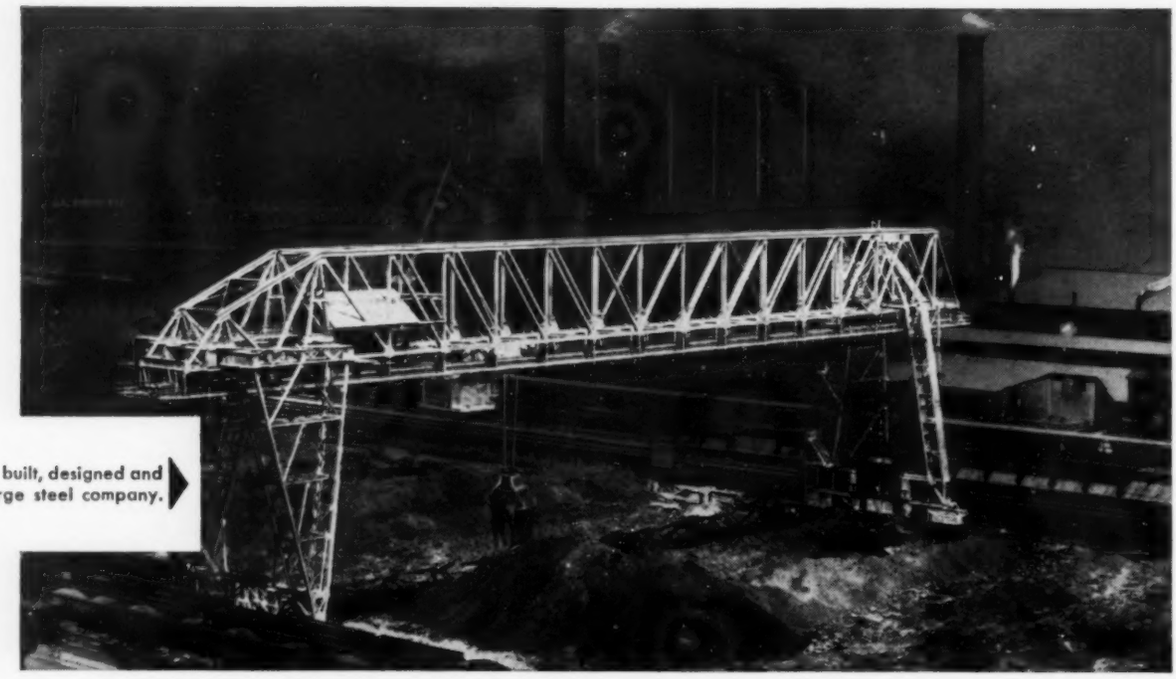

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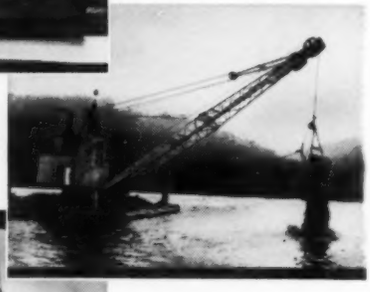
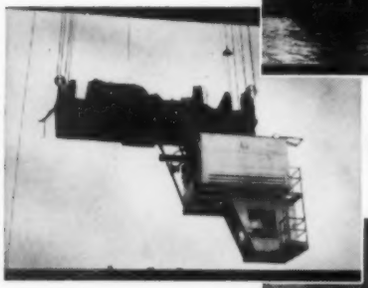
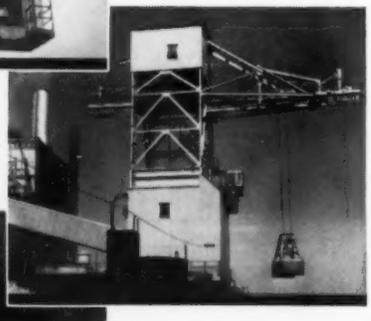
Travelling unloading towers built to handle imported iron ore at an Atlantic port.



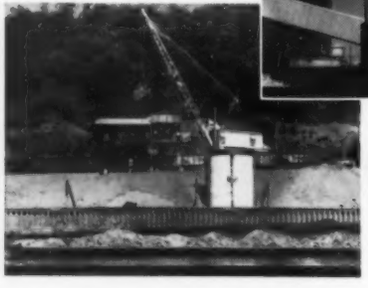
Whirler crane mounted on pontoon hull is used for dredging and general contract work.



Light-weight man trolley installation increased bridge handling capacity 60%.



Coal unloader designed and built for a large mid-western electric power company.



Stationary whirler crane designed and built to transfer coal from barges to hopper cars.

Over-all economical and safe performance is best obtained by using materials-handling equipment designed to suit your operating conditions. If you're planning a new materials-handling installation, we suggest an early "Round Table" session with Dravo engineers.

From actual experience over the past 60 years in building and installing the equipment shown here, valuable data is available in working out the features you want in your installation. This information, along with your own operating experience, can be used to create a design incorporating all the best features for easy maintenance, a high safety factor and simple, economical and satisfactory operation.

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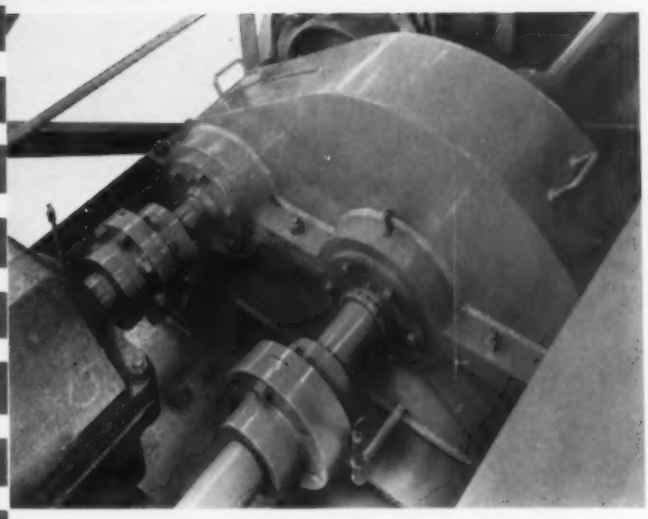

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MULTI-PURPOSE

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HEAVY-DUTY

HOUGHTO-GEAR E. P. OILS

Today's high-production equipment demands the extra protection and durability of Heavy Duty Houghto-Gear E. P. Oils. For these oils—extreme pressure treated—stand up under loads impossible for standard oils. That's because *Houghto-Gear* oil is fortified for extra high film strength. Moreover, its ability to cling securely to metal surfaces means your equipment will run longer with greater safety.

Your Houghton Man will be glad to make recommendations of these two Houghton Lubricants for your particular needs. Get in touch with him or write to E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

COSMOLUBE E. P. GREASE
HOUGHTO-GEAR E. P. OILS

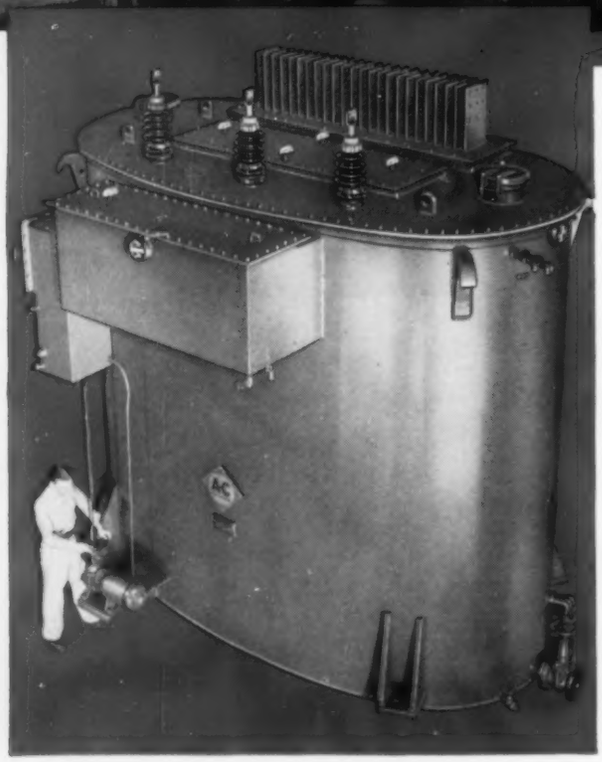
. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Reduce Cost of



TRANSFORMERS

Well-balanced design and extra-heavy duty construction are used in the Allis-Chalmers arc-furnace transformer. Past records show ability to withstand as much as 25 to 30 years of the repeated daily short circuits encountered in furnace operation. Extremely heavy supports and structure are used to brace coils against the severe short-circuit stresses.

Skillful insulation techniques protect windings from overvoltage due to wide tap range. Some units are designed for as much as 50% range in secondary voltages. Tap-changing mechanism, specially designed for arc-furnace transformers, is in separate compartment to facilitate maintenance. Wide flat contacts provide the long life needed for numerous daily tap-changing operations.

ALLIS-

Arc-Furnace Steel

Use Allis-Chalmers Integrated Electrical Equipment—and you...

SAVE **on Engineering** — Allis-Chalmers steel mill specialists coordinate equipment, submit single complete package proposal.

SAVE **on Purchasing** — One order, one invoice, one follow-up for the complete furnace electrical system.

SAVE **on Installation** — All components are matched for easy installation. Delivery is coordinated to prevent delays.

SAVE **in Operation** — All equipment is designed and built to work together. One reliable supplier guarantees performance of complete electrical system.

TAKE ADVANTAGE of Allis-Chalmers complete line of arc-furnace equipment—transformers, *Regulex* control, switchgear, associated controls—backed by 45 years of experience. Call your nearby Allis-Chalmers District Office for assistance when you are planning new facilities or modernization. Or write Allis-Chalmers, Milwaukee 1, Wisconsin.

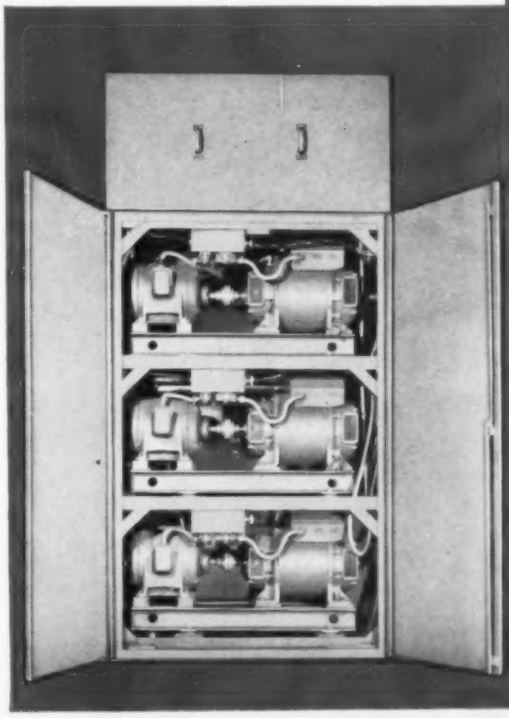
Regulex and *Ruptair* are Allis-Chalmers trademarks. A-4742

REGULEX CONTROL

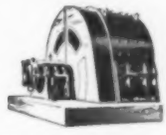
Balances arc current with arc voltage almost instantly—maintains desired arc conditions by automatically varying distance between electrode and charge.

With *Regulex* rotating amplifier there are no contacts or switching devices between the regulator and electrode motor. Continuously closed circuit provides constant positive control, minimizing current surges, cutting power consumption.

Simple design of *Regulex* results in lower maintenance. Provisions for spare unit mounted on top assure continuous operation under all conditions. Tier construction — open or enclosed —conserves valuable floor space.



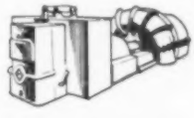
Other Allis-Chalmers Equipment for the Steel Industry



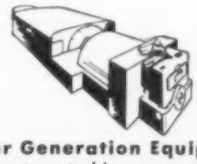
Wide Range of Motors for main mill and auxiliary equipment drives—ac or dc—from 1 hp to 10,000 hp—and supporting m-g sets or rectifiers.

Transformers for mill service include metering transformers, distribution transformers, power transformers, and unit substations.

Switchgear ranges from low voltage metal-enclosed units to large metal-clad types — includes *Ruptair* and oil circuit breakers. Also large power circuit breakers.



Blast Furnace Blowers are a part of the A-C line of single and multi-stage blowers, axial and rotary compressors, and vacuum pumps for the steel industry.



Power Generation Equipment includes steam turbine-generator units 2000 kw and larger for fluctuating steel mill loads. Also condensers, pumps and auxiliary-drive motors.

CHALMERS

A-C ALLIS CHALMERS

Pumping Progress Report

FOR HYDRAULIC ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

THE USE OF FLAMMABLE OIL as a hydraulic medium has two major objections — cost and the ever-present danger of fire. Providing a system that would overcome these objections was the problem presented to Aldrich Engineers by a manufacturer of die-cast parts for the automotive industry.

MAKE-UP OIL COST, for this manufacturer, was almost unbelievably high. The fire risk was great. Despite the best efforts of safety control, flash fires were inevitable.

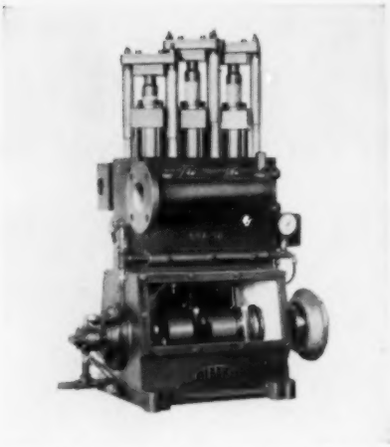
ONE SOLUTION was to pump water as the hydraulic fluid. But the manufacturer knew from experience that an ordinary pump couldn't do this job. What would we recommend?

WATER AS THE HYDRAULIC MEDIUM was our answer. And because Aldrich Direct Flow Pumps can pump water successfully, this manufacturer now operates a low cost, fire-free central hydraulic system. This die-caster gained other advantages by changing to his Aldrich-engineered central system. Aldrich Direct Flow Pumps feature fluid-end sectionalization, with a greater economy of maintenance and repair than was previously possible, horizontal valve action, parts standardization and simplicity of construction.

ALDRICH ENGINEERS will gladly consult with you on any pumping problem. Data Sheets describing the Aldrich series of Direct Flow Pumps will be sent to you on request. Ask for Data Sheet

63 — 2½" Stroke, 25 hp. Triplex
64A — 3" Stroke, 50 hp. Triplex
64, 64B — 5" Stroke, 100 to 200 hp. Series
67A — 6" Stroke, 300 to 900 hp. Series

Address your request to: The Aldrich Pump Company, 21 Pine Street, Allentown, Pa.



2½" Stroke, Triplex "POWR-PAC" Pump

...for your tough pumping problems specify ALDRICH

Solving tough pumping problems has become a specialty with Aldrich. Today, manufacturing plants from coast to coast are performing routine pumping assignments around the clock that were once real headaches for project and plant engineers.

Aldrich Direct Flow Pumps, the basis for solving most of these problems, feature design innovations that provide economies of operation, maintenance and repair in addition to performing jobs not possible with ordinary pumps. If you have a pumping problem, pass it on to us.

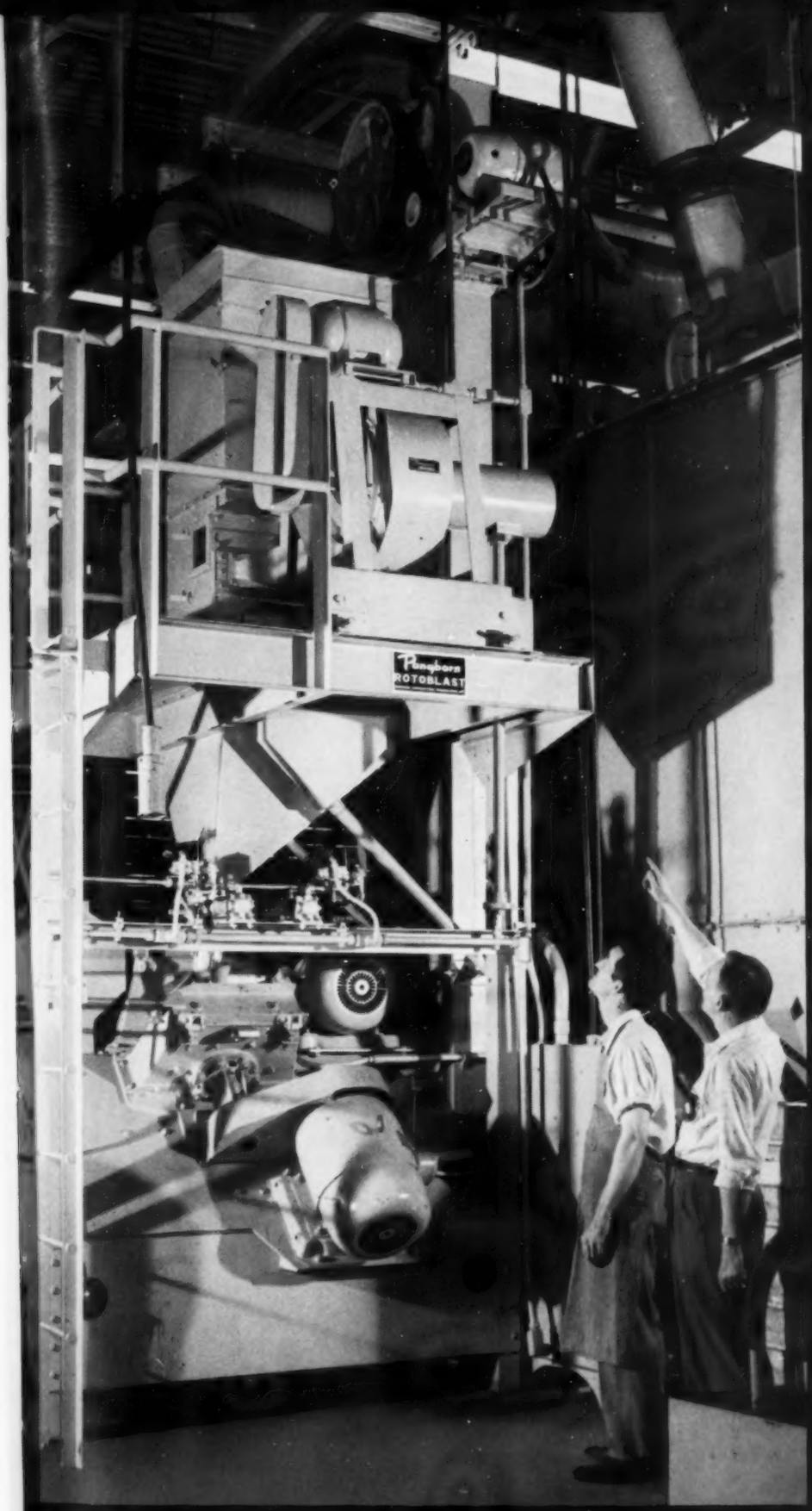
TYPICAL METAL WORKING APPLICATIONS FOR ALDRICH PUMPS:

Descaling — Die Casting
Roll Balancing — Press Operation
Hydraulic Testing

Write today for Data Sheets describing the Direct Flow Pump Series.

THE ALDRICH PUMP COMPANY

Originators of the Direct Flow Pump
21 PINE STREET
ALLENTOWN, PA.
Representatives in principal cities



This special Pangborn Rotoblast® machine saves Hamilton Standard $20,000 a year!

The special Pangborn Rotoblast Blast Cleaning Machine at left was designed by Pangborn for Hamilton Standard Division of United Aircraft Corp. This installation is used for blast cleaning and shot peening . . . saving Hamilton $20,000 a year. Below is another special Pangborn machine, owned by Parish Pressed Steel Division of Dana Corp., Reading, Pa. This Rotoblast Descaling Machine is used to clean steel sheets and coiled strip ranging in widths from 19″ to 60″ at a line speed of from 80′ to 150′ per minute.

These are just two of hundreds of special Pangborn machines used throughout the country—to clean parts that are fragile, odd-size or present some other obstacle to usual cleaning methods. If you have such a problem, Pangborn engineers will study it and its relation to your production line. The result will be a Pangborn machine designed especially to give *you* better cleaning and faster production at lower cost. Write today for Bulletin 227 to PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

Pangborn

BLAST CLEANS CHEAPER

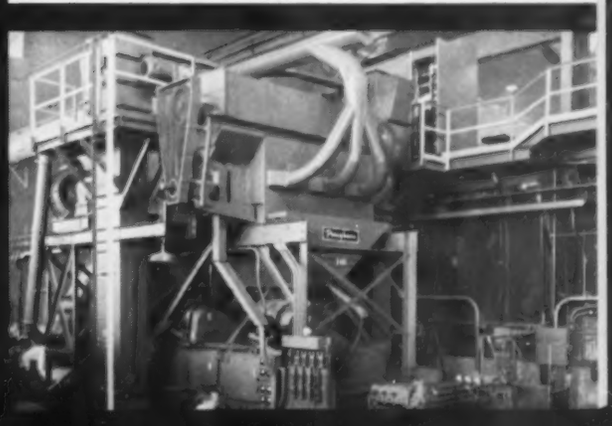
Rotoblast Blastmaster® & Continuous-Flo Barrel

Rotoblast Tables & Table-Rooms

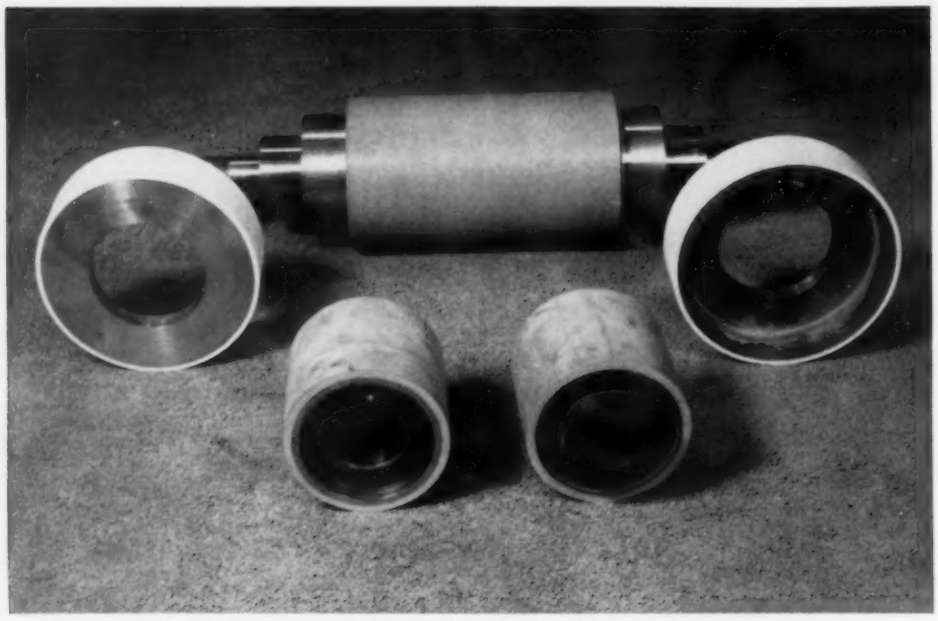
Special Blast Rooms & Cabinets

Pangborn Dust Control Equipment

Malleabrasive Shot & Grit



THE MIRACLE MATERIAL FOR YOUR ROLL PROBLEMS



Specialty roll for Shear, Finishing and Cold Mill finished products.

SPEC PLASTIC ROLLS

STRENGTH • DURABILITY • LIFE

Special applications require special roll characteristics — acid and moisture resistance, ability to withstand high temperatures, abrasion and friction qualities, etc. SPEC plastic-coated rolls are proving in plant after plant that they do the job better and last three to five times longer than rubber-coated rolls.

Next time you have a special roll problem, call one of our district offices, or send in your problem direct to the home office, and let us help you take it out of the red on your production, replacement, and maintenance costs. You'll be glad you did.

ANNEALING PICKLING SCRUBBING FINISHING ELECTRO-TINNING

STEEL PLANT EQUIPMENT CORPORATION

Specialists in Covered Rolls

3117 Grant Building • Pittsburgh 19, Pa. • EXpress 1-3277

Representatives:

T. A. REILLY COMPANY.....139 N. Clark St., Chicago 2, Illinois
Phone — Franklin 2-3474

J. E. KIEFER COMPANY.....P. O. Box 3193, Youngstown 12, Ohio
Phone — Sterling 2-6386

DeSHAZO-THOMAS..107 Broadway, P. O. Box 5822, Birmingham 9, Ala.
Phones — Tremont 1-4127; Tremont 9-6610

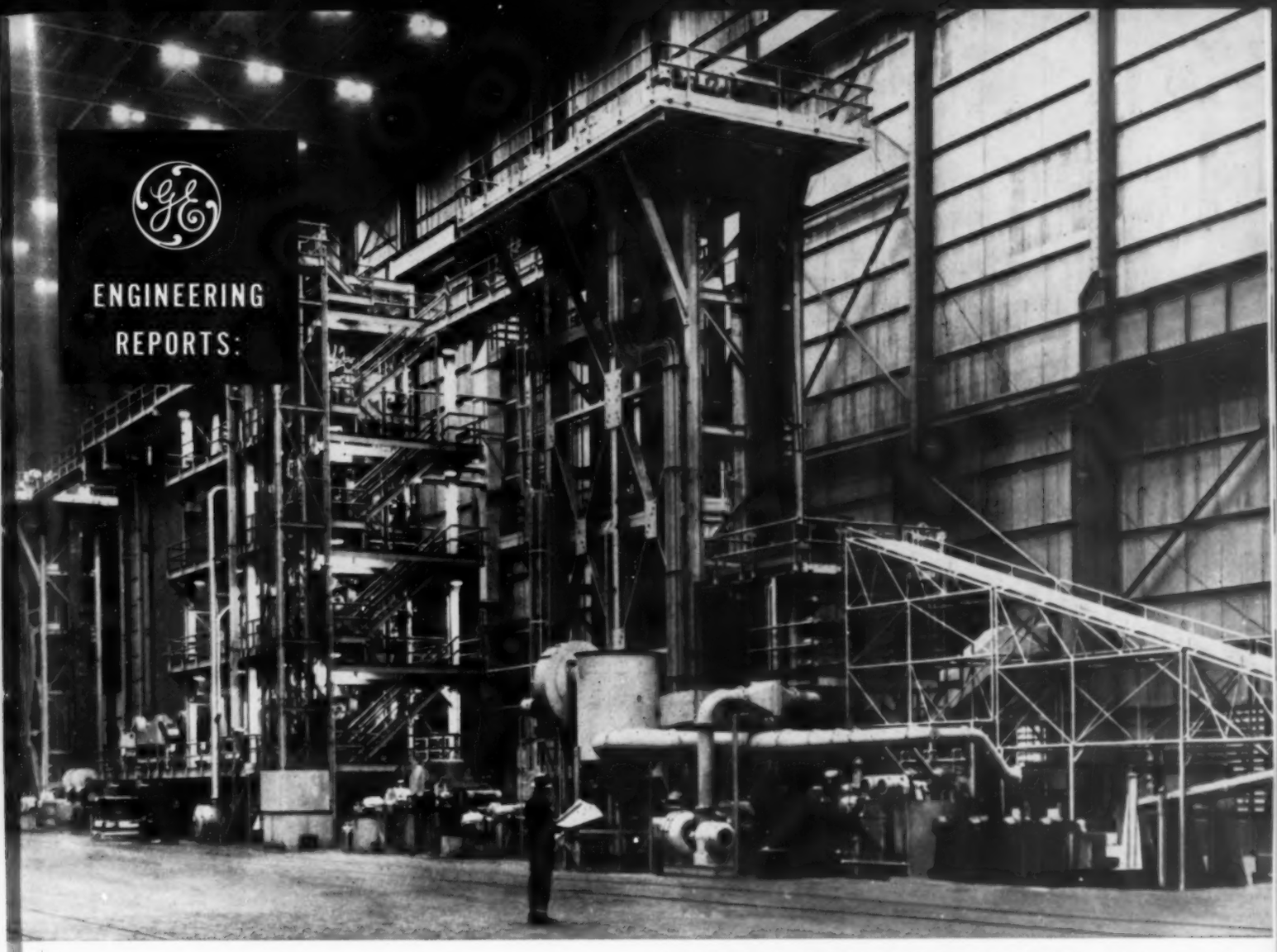
EMPIRE ENG. CO.....385 East Green Street, Pasadena 1, California
Phone — Ryan 1-6178

A. M. McINTYRE.....8226 Buchanan Street, St. Louis 14, Missouri
Phone — Harrison 83940

HIGGINSON ENGINEERING CO.....275 James St. North, P. O. Box 23, Hamilton, Ontario, Canada

THOMAS J. DEMPSEY, JR..... 321 Investment Bldg., Pittsburgh 22 Pa.
Phone — Grant 1-8370

STEEL PLANT EQUIPMENT CORP.....Room 50, Curren Arcade Bldg., Norristown, Pa. Phone — Norristown, Pa. 5-7539



G-E VERTICAL ANNEALING FURNACE at Fairless Works is one of largest in world. Strip is annealed at rate of 1000 fpm

Drive-engineered by General Electric . . .

New Fairless line anneals 30 tons/hr

Running at speeds up to 1000 feet per minute, U. S. Steel's new cleaning and annealing line at their Fairless Works, Fairless Hills, Pa., produces clean, bright, uniformly annealed strip at the rate of 30 tons per hour. This continuous processing line is a typical example of the drive-engineering and equipment applied to many of the new Fairless lines by General Electric.

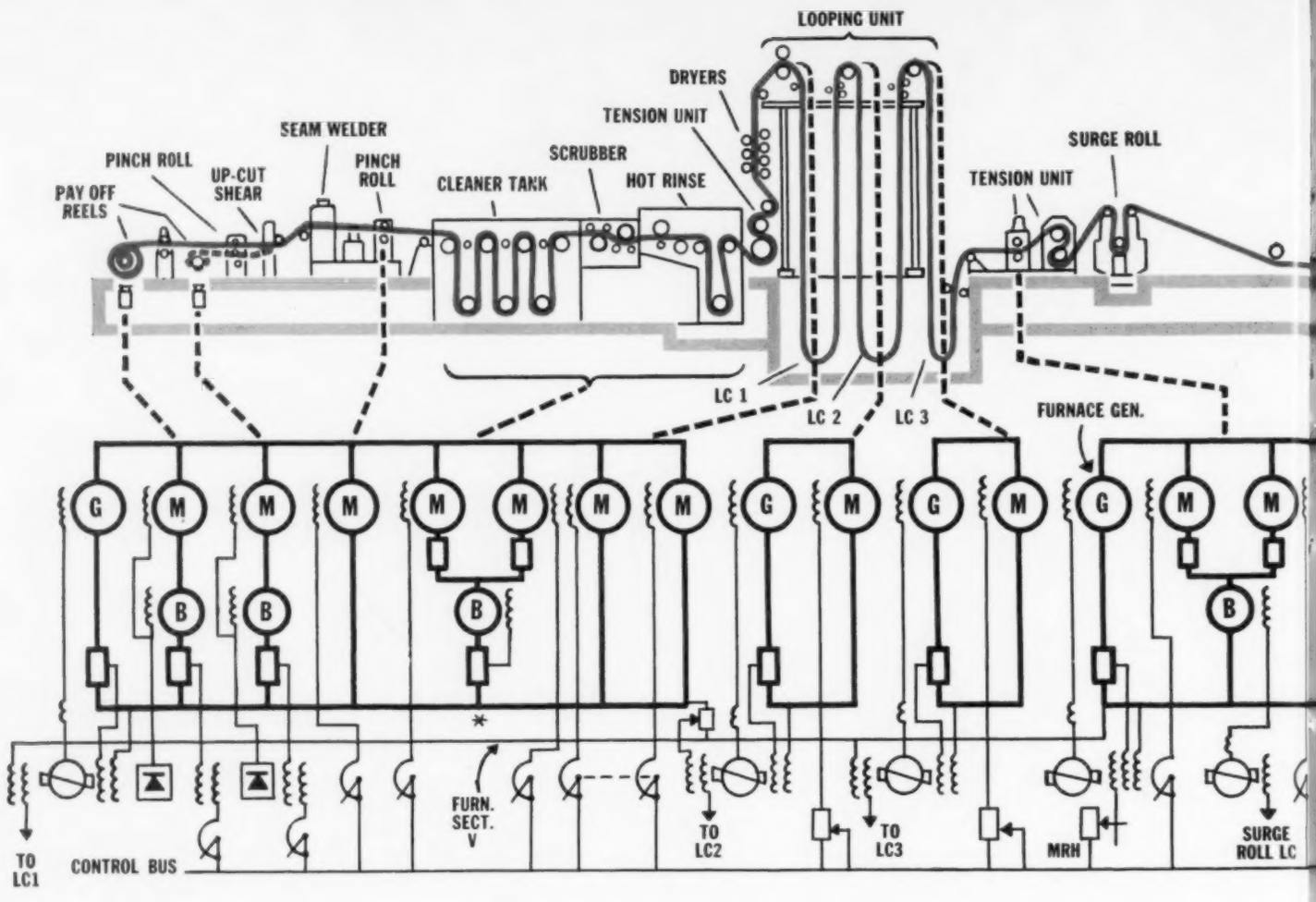
It is also another example of the teamwork performed between the customer, his machinery builder, and General Electric. Engineers from U. S. Steel, United Engineering and Foundry Co., and General Electric worked together to design this annealing line which is one of the fastest in operation today.

The entire line operates under automatic control, and handles strip from 18 to 37 inches wide. The use of a G-E annealing furnace—one of the world's largest—and vertical loops permits the accommodation of 3000 feet of strip between the two ends in a floor length of only 385 feet.

The same G-E engineering skill which was utilized on this high-speed annealing line is available to you. If you are planning to build, expand, or modernize your facilities, contact your Apparatus Sales Representative at the nearest G-E Apparatus Sales Office. General Electric, Schenectady, N. Y. 659-107

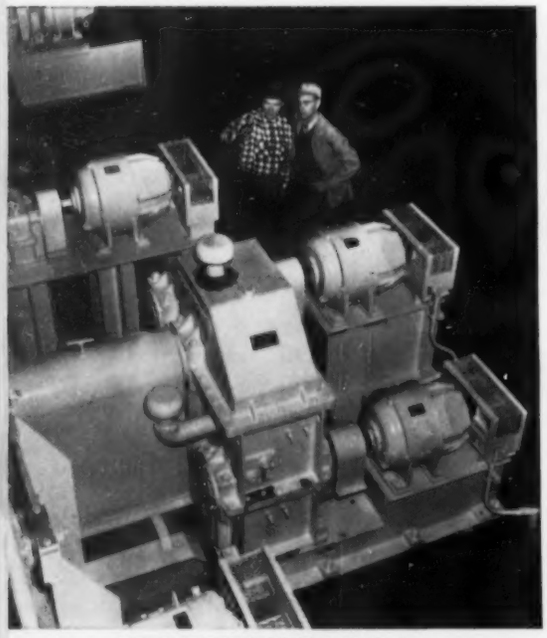
ADVANTAGES OVER BATCH METHODS

GENERAL ELECTRIC



Powered by a General Electric drive system...

New Fairless continuous annealing line



ADJUSTABLE SPEED G-E d-c motors on tension bridle help maintain constant strip tension in furnace.

AUTOMATIC CONTROL of gas fired and electrical heating and cooling zones of furnace is provided by G-E control unit.

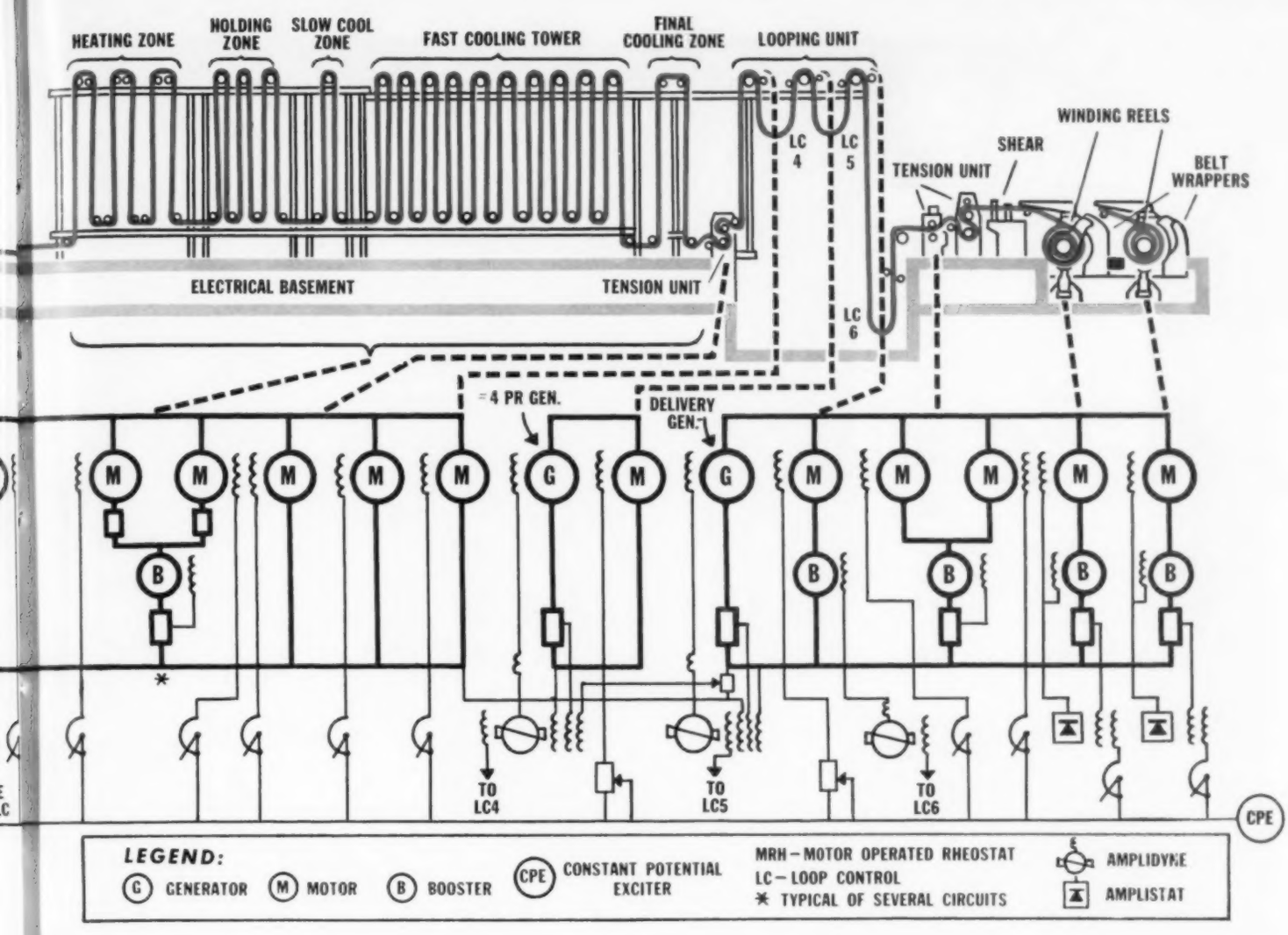
COMPACT G-E control center for fans, pumps, and auxiliary m-g sets is located in electrical basement.

HOW THIS DRIVE WORKS

A motor-operated rheostat sets line speed by controlling the furnace-section generator voltage. Voltages of the entry and delivery section drives, and the tower pinch rolls, are regulated to keep the entry storage loops full and the delivery storage loops empty during normal running. The furnace-section voltage is used as a reference for an approximate speed match, with the photoelectric loop controls (LC) acting as over-riding vernier regulators to maintain accurate loop position.

To start a new coil, the entry section is decelerated to a stop under current limit, while the "half-speed pinch roll" (No. 1PR) empties the loops evenly. This permits the strip to continue through the furnace at a constant speed during the time required to weld toegther the ends of the new and old coils. The entry section is then accelerated, again under current limit, to an overspeed condition until the storage loops are refilled. Full coils of annealed strip are removed from the delivery end of the line in a corresponding manner.

Another example of G-E drive engineering at work!



has 5 advantages over batch methods

1 Increases output **2** Improves product **3** Saves time

4 Saves manpower **5** Saves space

Fairless' new continuous cleaning and annealing line at Fairless Hills, Pa., is an excellent example of the progress that has been made in the continuous processing field. Powered by a General Electric drive system, the new line, which can process 30 tons of steel per hour at speeds up to 1000 fpm, has these five advantages over batch methods.

1. **INCREASES OUTPUT.** Continuous high-speed operation of line 24 hours a day speeds output.
2. **IMPROVES PRODUCT.** Precise temperature control of furnace gives strip greater uniformity, with improved flatness, and cleaner surface.
3. **SAVES TIME.** High speed of line reduces coil annealing time from days to minutes. There is no need to transport coils from cold mill to cleaning unit to furnaces.
4. **SAVES MANPOWER.** Amplidyne control of tension, loop positioning, and overspeeding provides high degree of automatic operation.
5. **SAVES SPACE.** By combining cleaning and annealing, floor space is reduced by more than a third.

You also profit when you specify General Electric to help design your continuous processing line electrical systems. Experienced G-E steel mill processing line engineers are available to work with you and machinery manufacturers to construct modern, high-speed lines. For further information, contact your G-E Apparatus Representative, or write for bulletin GEA-6017, "Engineered Electrical Systems for Continuous Metal Processing." General Electric Co., Schenectady, N. Y.

659-107

Engineered Electrical Systems for Steel Mills

GENERAL ELECTRIC

Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops and Shorts

EARNINGS reported by the various steel companies for the first half of 1955 are pretty generally up 50-100 per cent over the first half of 1954. In many cases, earnings have broken all-time records, but before we get too excited about that, we must remember that dollar-values today aren't what they used to be. A ton of annual capacity today costs about $300, while capitalization of the industry is about $55. Hence, it's going to take a lot more dollars to replace the equipment that is wearing out . . . and replaced it must be.

Also, a 30-year comparison of net profits of manufacturing industries, in per cent of net worth, shows steel about 35th in a list of some 44 industries.

The most heartening thing about the reports are the accompanying statements predicting good business through the rest of 1955 and well into 1956. Optimism grows as tonnage mounts. Looking back at the year-end predictions, we find most of them on the low side. In fact, Admiral Ben Moreell's prediction of a possible new record—over 111,000,000 tons of steel—now looks to be closer than most of the other estimates.

▲

THE Wall Street Journal says that Davy Crockett not only subdued Indians and other foes of his day but in 1955 he succeeded in practically wiping space men off the map.

▲

ADMIRAL Ben Moreell, chairman of Jones and Laughlin Steel Corp., thinks recent steel price increases inadequate, as they average only 5.8 per cent against the wage increase of 7.5 per cent. He believes the steel industry must protect its earnings position, as it must "attract $9,000,000,000 in new investment money" in the next decade.

▲

WE hope that Herbert Hoover's suggestions as to how the government can save money get more attention than similar ideas do at home.

▲

A. B. HOMER, president of Bethlehem Steel Corp., told a Senate committee that the merger of Bethlehem and Youngstown Sheet and Tube would bring capital improvements totaling $350,000,000 in the latter's Chicago and Youngstown plants. Ingot capacity of these plants would be increased by about 3,000,000 tons per year.

PEOPLE who complain about gobbledegook in government communications can take heart from this memorandum issued by the Rural Electrification Administration: "Bermuda shorts — anything BUT!"

▲

FIGURES compiled by the American Iron and Steel Institute show that the steel industry had nearly 770,000 stockholders at the end of 1954, and 762,830 employees. This is the first time in many years that stockholders outnumbered employees.

▲

SUMMERTIME must be conducive to perplexing questions. The Houghton Line raised the question: "Why do suburbanites work so hard all spring on grass and flowers, then take their families away for the summer?"

And Professor W. Trinks called to ask why business men work bare-headed and in shirt sleeves in their air-conditioned offices and put on hats and coats when they go out in the heat.

What's bothering us is why the girls call their trousers slacks when there's never any slack in them.

▲

IT'S hard to make people outside of the industry believe it, but the steel industry is one of the safest of all industries. The steel industry's disabling injury frequency rate for 1954 was 3.85 per million man-hours worked—an all-time low. The average for all industries was 7.22. And U. S. Bureau of Labor Statistics for the first quarter of 1955 show basic steel holding 15th place in the safety records of 130 manufacturing industries.

▲

IN spite of all the complaints about today's dollar, we haven't found anyone turning them down.

▲

THE July issue of the Journal of the Iron and Steel Institute describes a water-cooled periscope which can be inserted into an open hearth furnace and give an effective view of the inside of the furnace. The field of view is adequate to cover any portion of the furnace interior when inserted through a single hole in the front or back wall. The equipment can be used either for direct observation or for photography.

▲

INSTEAD of funneling all of the fruits of increased productivity into ever higher wages, which affects only about one-fourth of the workers, maybe some should be distributed more widely through lower prices. This would benefit all consumers.

▲

UNITED Air Lines is now providing slippers, cocktails and steak dinners on special "men only" flights between New York and Chicago—and pipe and cigar smoking is permitted.

▲

STARTING salaries for engineering graduates continue to increase. Illinois Institute of Technology 1955 graduates averaged $381 per month, compared with $363 in 1954. In 1949, the average was $282.

From one source . . . any instrumentation you need

When it comes to measurement and control, every industrial process is different. Each demands its own combination of accuracy, economy, instrument ranges, and all the numerous other characteristics that are peculiar to the individual application.

No single instrument and its accessories could possibly fit every process. So Honeywell makes a broad variety of measuring and controlling equipment that spreads across a tremendous range of applications.

The advantages are two-fold. First, you can get all the instrumentation your process requires from a single source, so there is undivided responsibility for the complete installation. And second, you are assured that the equipment selected for your process is recommended without bias . . . neither over-sells nor under-equips . . . needs no stretching, squeezing or compromising to fit it to its assignment.

This versatile family includes *ElectroniK* indicators, recorders and controllers in circular and strip chart models, applicable to temperature, pressure, pH, power and dozens of other variables; square root flow meters for control applications; evenly graduated flow meters for cost accounting; thermometers, pressure gauges and liquid level meters; *Pyr-O-Vane* millivoltmeter controllers. Especially useful for graphic panels are the *Tel-O-Set* miniature indicators, recorders and controllers. Electric and pneumatic control systems range from the simplest to the most complex, including automatic program controls and complete systems developed for particular processes.

Working with these instruments is a full choice of primary elements . . . thermocouples, *Radiamatic* radiation elements, pressure-type and electrical resistance thermal systems, flow meter bodies, pH cells and many others. For final control elements, you can choose from a wide range of electric motorized and diaphragm operated valves. To complete the picture, there are more than 7000 non-indicating devices for controlling temperature, pressure, vacuum, liquid level and humidity . . . an unmatched variety of instrumentation made by the world's largest manufacturer of control equipment.

Brown control helps Alan Wood use by-product f

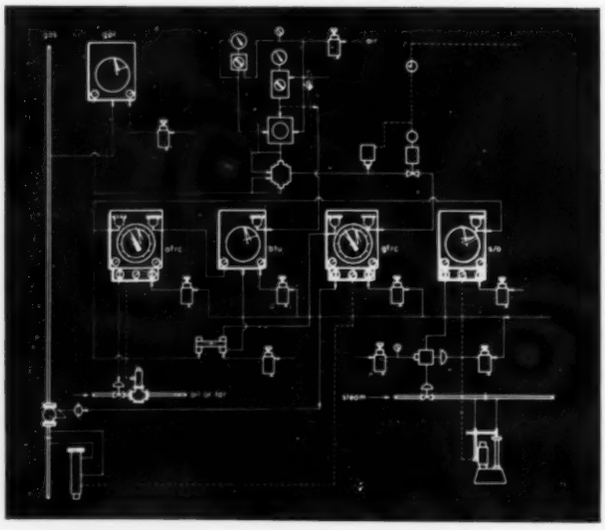
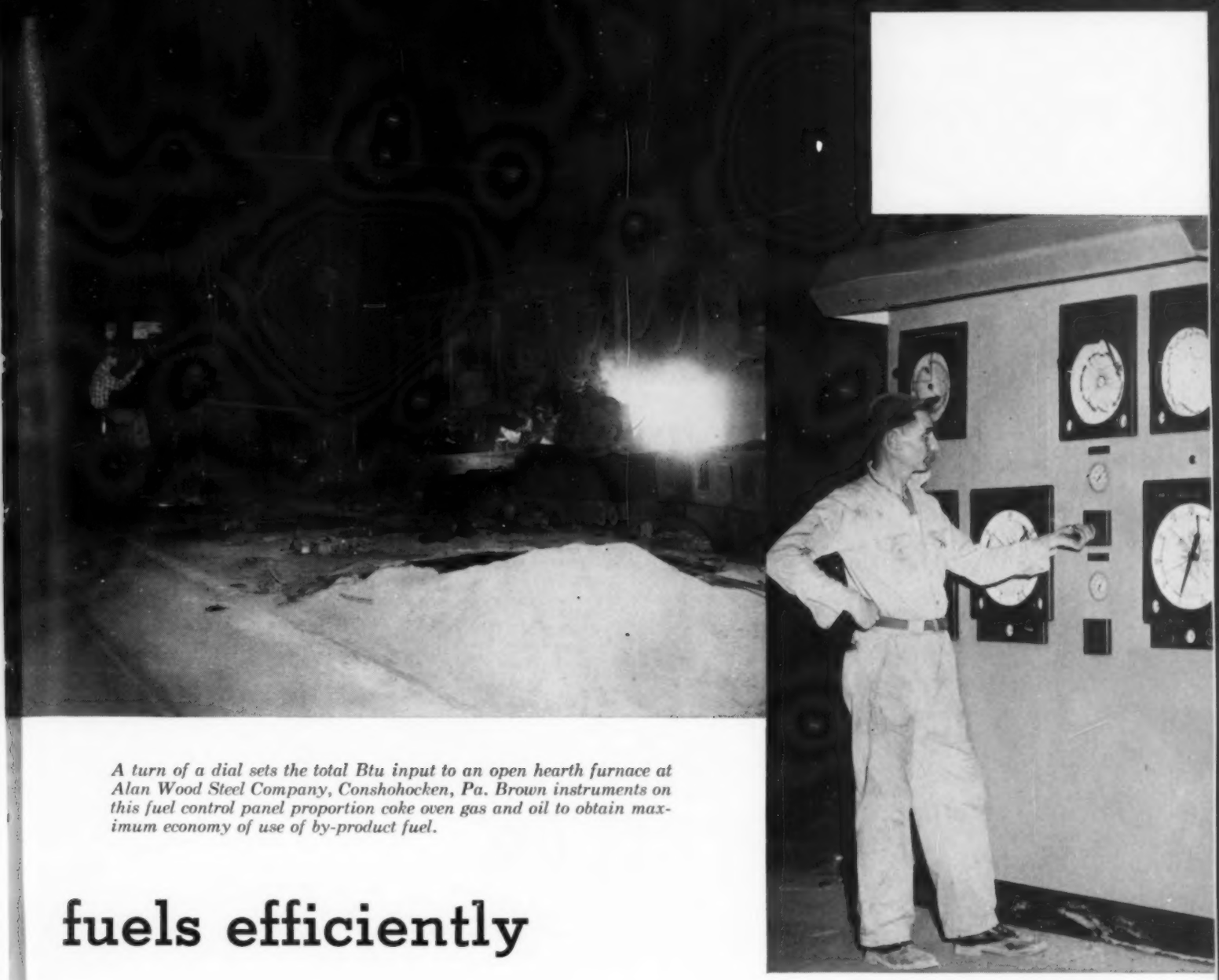


Diagram shows elements of the Brown fuel control system for mixed-fuel firing of an open hearth furnace. Instruments include gas pressure recorder, oil flow controller, gas flow controller, total Btu controller and steam flow controller



A turn of a dial sets the total Btu input to an open hearth furnace at Alan Wood Steel Company, Conshohocken, Pa. Brown instruments on this fuel control panel proportion coke oven gas and oil to obtain maximum economy of use of by-product fuel.

fuels efficiently

ECONOMICAL utilization of by-product fuels can prove the means of substantial cost reductions in steel mill operations. Alan Wood Steel Company accomplishes this objective with the help of an integrated Brown control system applied to its open-hearth furnaces.

The control system mixes coke oven gas with the base fuel, which is oil or tar. It automatically uses as much of the coke oven gas as is available . . . then proportions the base fuel to provide the required total Btu input. In addition, it regulates combustion air to maintain the desired fuel-air ratio for efficient combustion.

Operation is fully automatic. The operator sets the Btu input he wants, and the instruments decide whether coke oven gas is available . . . proportion it to oil feed . . . and adjust air flow in accordance. The operator can take over by means of remote manual control units, when necessary.

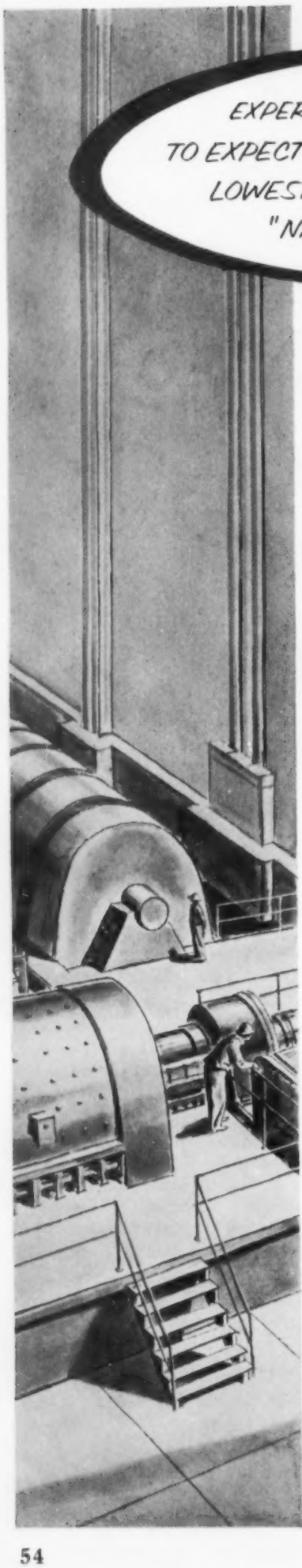
On the instruments, fuel engineers get a complete record of gas and oil flow, Btu input and gas pressure . . . from which detailed analysis of each heat can be made. The charts also help to show operators related trends in values important to fuel economy in the particular furnace.

Brown fuel-air ratio control systems, custom-designed for your specific requirements, can help you maintain high efficiency and economical operation of any furnace. For a discussion of your application, call your local Honeywell sales engineer . . . he's as near as your phone.

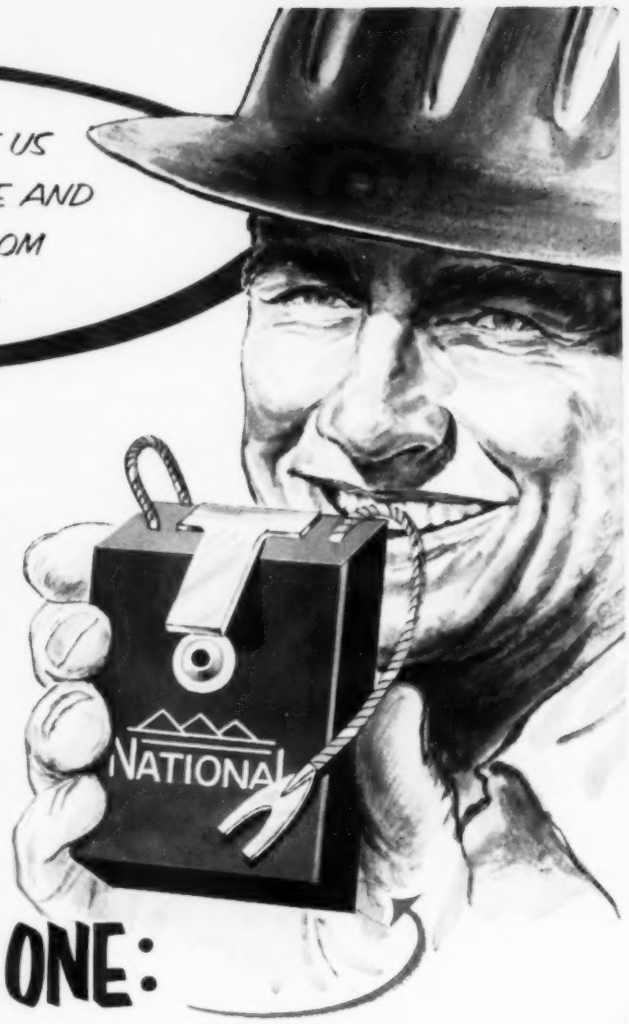
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:** Write for Data Sheet No. 4.3-4a, "Fuel-Air Ratio Control Systems for Metallurgical Furnaces.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls



EXPERIENCE HAS TAUGHT US TO EXPECT TOP PERFORMANCE AND LOWEST OVERALL COST FROM "NATIONAL" BRUSHES.



LOOKING FOR WAYS TO SAVE MONEY? TRY THIS ONE:

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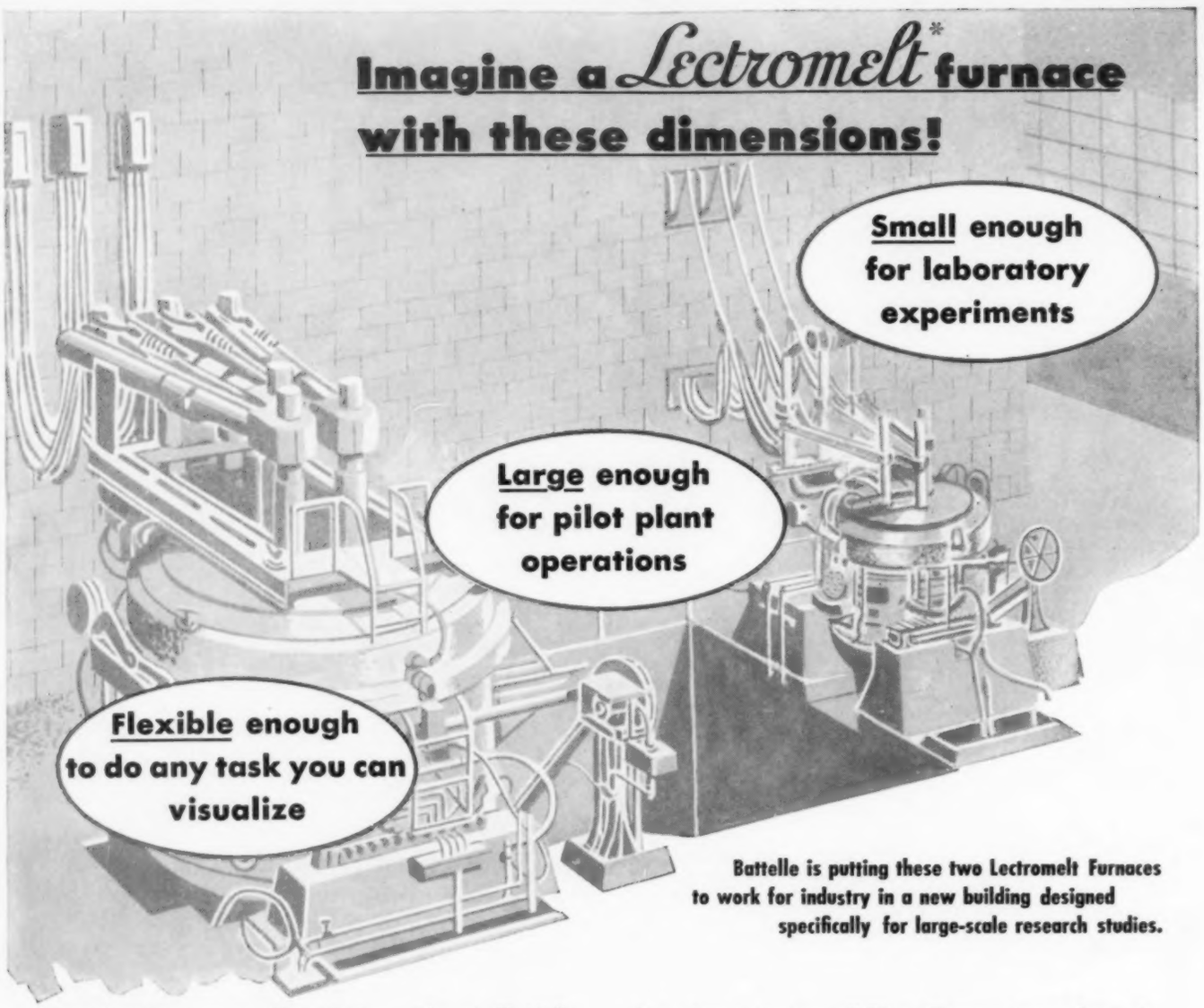
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HYDRAULIC SYSTEMS

on Charging Machines and Manipulators

By R. S. BOGAR

Assistant Chief Engineer, Bethlehem Steel Co., Johnstown, Pa.

. . . . initial use of hydraulic systems on steel plant charging equipment demonstrated that for steel plant service the following features are necessary in the equipment . . . . simplicity, ruggedness, accessibility, ease of unit replacement and ability to overcome high temperature conditions . . . . actual operation also found it desirable for plant personnel to make regular inspections, periodic adjustments, and regularly scheduled oil tests . . . .

▲ CHARGING machines for open hearths and heating furnaces, and manipulators for various forging and rolling operations, have been utilized as essential workhorses by the steel industry for the last half century or more. Most of these machines have at least two motions in common—the hoist, and the grip, clamp, or lock.

Originally, and for many years until rather recently, the hoist and grip motions were for the most part mechanically operated. This is understandable in view of the fact that until the last several decades or so, hydraulic equipment in most steel plants was limited to such massive and slow-speed applications as forging and shaping presses, roll balances, bloom shears, blooming mill manipulators, tilting tables, and the like.

During World War II, the hydraulic art developed at a tremendous pace both industrially and militarily. Machine tools with hydraulic components became commonplace, while thousands of applications were made on tanks, ships, and airplanes for all types of precise, high-speed motions.

After the war, the application of hydraulic power to the hoist and grip motions of charging machines and manipulators was investigated and found to offer a number of advantages over the time-proven mechanical drives.

Consequently, many of the hydraulic machines have been built and put into service in the last six or eight years.

Experience with these machines has borne out many of the claimed advantages of the hydraulic drives, but this same experience has also uncovered many "bugs" in the original designs which have required extensive and intensive study and revision by the maintenance departments of the plants before the machines could be considered to be satisfactory from a repair and maintenance standpoint.

It is the purpose of this paper to discuss some of these detective and remedial measures so that others may benefit by this experience and be spared the painful cut-and-try period through which many have gone.

In scope, attention in considerable detail will be focused upon six hydraulic open hearth charging machines in one plant, which are representative of most of the problems common to hydraulic machines. In this same plant, brief consideration will be given to three axle plant manipulators, one axle plant charger, and one plate mill charger. Reference will also be made to five open hearth charging machines in three other plants.

Inasmuch as this paper deals primarily with hydrau-

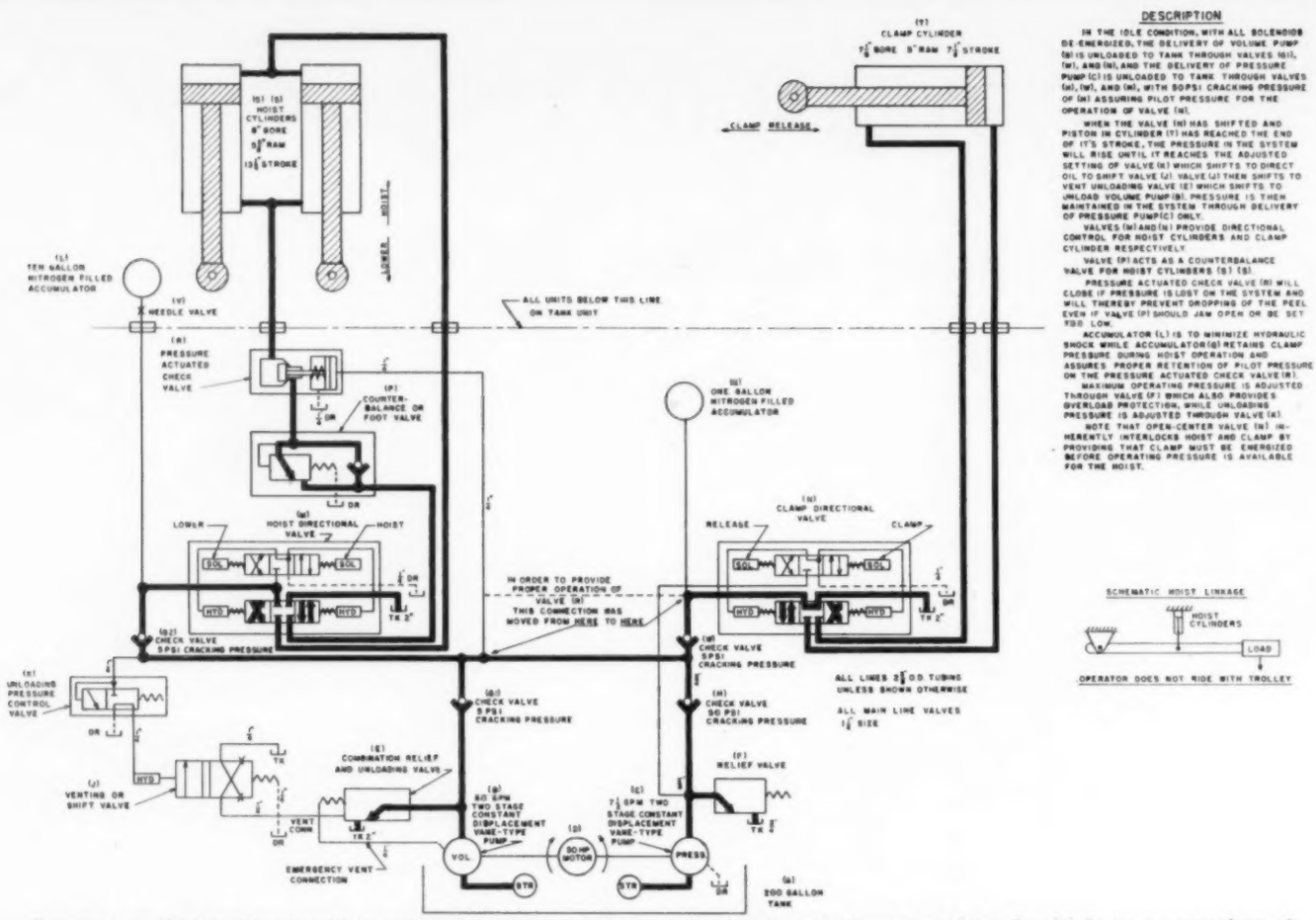
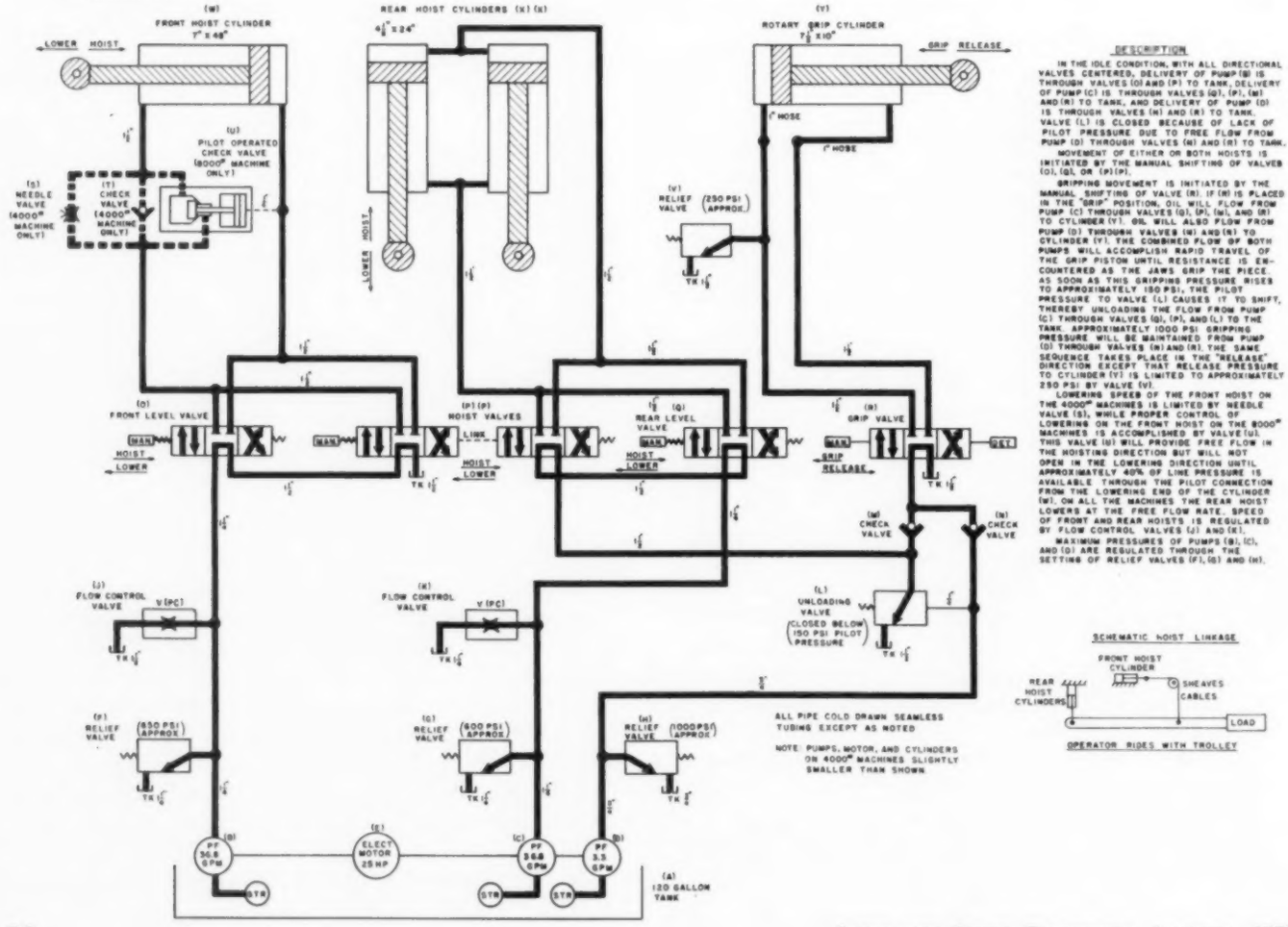

DESCRIPTION
IN THE IDLE CONDITION, WITH ALL SOLENOIDS DE-ENERGIZED, THE DELIVERY OF VOLUME PUMP (B) IS UNLOADED TO TANK THROUGH VALVES (G), (M), AND (N), AND THE DELIVERY OF PRESSURE PUMP (C) IS UNLOADED TO TANK THROUGH VALVES (J), (M), AND (N), WITH 50PSI CRACKING PRESSURE OF (H) ASSURING PILOT PRESSURE FOR THE OPERATION OF VALVE (M).
WHEN THE VALVE (N) HAS SHIFTED AND PISTON IN CYLINDER (T) HAS REACHED THE END OF IT'S STROKE, THE PRESSURE IN THE SYSTEM WILL RISE UNTIL IT REACHES THE ADJUSTED SETTING OF VALVE (K) WHICH SHIFTS TO DIRECT OIL TO SHIFT VALVE (J) VALVE (J) THEN SHIFTS TO VENT UNLOADING VALVE (E) WHICH SHIFTS TO UNLOAD VOLUME PUMP (B). PRESSURE IS THEN MAINTAINED IN THE SYSTEM THROUGH DELIVERY OF PRESSURE PUMP (C) ONLY.
VALVES (M) AND (N) PROVIDE DIRECTIONAL CONTROL FOR HOIST CYLINDERS AND CLAMP CYLINDER RESPECTIVELY.
VALVE (P) ACTS AS A COUNTERBALANCE VALVE FOR HOIST CYLINDERS (S) (S).
PRESSURE ACTUATED CHECK VALVE (R) WILL CLOSE IF PRESSURE IS LOST ON THE SYSTEM AND WILL THEREBY PREVENT DROPPING OF THE PEEL EVEN IF VALVE (P) SHOULD JAM OPEN OR BE SET TOO LOW.
ACCUMULATOR (L) IS TO MINIMIZE HYDRAULIC SHOCK WHILE ACCUMULATOR (Q) RETAINS CLAMP PRESSURE DURING HOIST OPERATION AND ASSURES PROPER RETENTION OF PILOT PRESSURE ON THE PRESSURE ACTUATED CHECK VALVE (R).
MAXIMUM OPERATING PRESSURE IS ADJUSTED THROUGH VALVE (F) WHICH ALSO PROVIDES OVERLOAD PROTECTION, WHILE UNLOADING PRESSURE IS ADJUSTED THROUGH VALVE (K).
NOTE THAT OPEN-CENTER VALVE (N) INHERENTLY INTERLOCKS HOIST AND CLAMP BY PROVIDING THAT CLAMP MUST BE ENERGIZED BEFORE OPERATING PRESSURE IS AVAILABLE FOR THE HOIST.
SCHEMATIC HOIST LINKAGE
HOIST CYLINDERS
LOAD
OPERATOR DOES NOT RIDE WITH TROLLEY
CLAMP CYLINDER
CLAMP RELEASE
HOIST CYLINDERS
LOWER
HOIST
ALL UNITS BELOW THIS LINE ON TANK UNIT
NEEDLE VALVE
PRESSURE ACTUATED CHECK VALVE
COUNTER-BALANCE OR FOOT VALVE
ONE GALLON NITROGEN FILLED ACCUMULATOR
HOIST DIRECTIONAL VALVE
CLAMP DIRECTIONAL VALVE
RELEASE
CLAMP
IN ORDER TO PROVIDE PROPER OPERATION OF VALVE (N) THIS CONNECTION WAS MOVED FROM HERE TO HERE
CHECK VALVE 5PSI CRACKING PRESSURE
CHECK VALVE 50 PSI CRACKING PRESSURE
ALL LINES 2" O.D. TUBING UNLESS SHOWN OTHERWISE
ALL MAIN LINE VALVES 1" SIZE
UNLOADING PRESSURE CONTROL VALVE
VENTING OR SHIFT VALVE
COMBINATION RELIEF AND UNLOADING VALVE
RELIEF VALVE
EMERGENCY VENT CONNECTION
60 GPM TWO STAGE CONSTANT DISPLACEMENT VANE-TYPE PUMP
7 1/2 GPM TWO STAGE CONSTANT DISPLACEMENT VANE-TYPE PUMP
50 HP MOTOR
VOL
PRESS
200 GALLON TANK

Figure 1 — Hydraulic circuit is original two-pump system for hoist and clamp motions for high type open hearth charging machines.

Figure 2 — Hydraulic circuit is shown for hoist and grip motions for 4000 and 8000-lb capacity axle plant manipulating machines.


DESCRIPTION
IN THE IDLE CONDITION, WITH ALL DIRECTIONAL VALVES CENTERED, DELIVERY OF PUMP (B) IS THROUGH VALVES (O) AND (P) TO TANK, DELIVERY OF PUMP (C) IS THROUGH VALVES (Q), (P), (M) AND (R) TO TANK, AND DELIVERY OF PUMP (D) IS THROUGH VALVES (N) AND (R) TO TANK. VALVE (L) IS CLOSED BECAUSE OF LACK OF PILOT PRESSURE DUE TO FREE FLOW FROM PUMP (D) THROUGH VALVES (N) AND (R) TO TANK. MOVEMENT OF EITHER OR BOTH HOISTS IS INITIATED BY THE MANUAL SHIFTING OF VALVES (O), (Q), OR (P) (P).
GRIPPING MOVEMENT IS INITIATED BY THE MANUAL SHIFTING OF VALVE (R). IF (R) IS PLACED IN THE "GRIP" POSITION, OIL WILL FLOW FROM PUMP (C) THROUGH VALVES (Q), (P), (M), AND (R) TO CYLINDER (Y). OIL WILL ALSO FLOW FROM PUMP (D) THROUGH VALVES (N) AND (R) TO CYLINDER (Y). THE COMBINED FLOW OF BOTH PUMPS WILL ACCOMPLISH RAPID TRAVEL OF THE GRIP PISTON UNTIL RESISTANCE IS ENCOUNTERED AS THE JAWS GRIP THE PIECE. AS SOON AS THIS GRIPPING PRESSURE RISES TO APPROXIMATELY 150 PSI, THE PILOT PRESSURE TO VALVE (L) CAUSES IT TO SHIFT, THEREBY UNLOADING THE FLOW FROM PUMP (C) THROUGH VALVES (Q), (P), AND (L) TO THE TANK. APPROXIMATELY 1000 PSI GRIPPING PRESSURE WILL BE MAINTAINED FROM PUMP (D) THROUGH VALVES (N) AND (R). THE SAME SEQUENCE TAKES PLACE IN THE "RELEASE" DIRECTION EXCEPT THAT RELEASE PRESSURE TO CYLINDER (Y) IS LIMITED TO APPROXIMATELY 250 PSI BY VALVE (V).
LOWERING SPEED OF THE FRONT HOIST ON THE 4000# MACHINES IS LIMITED BY NEEDLE VALVE (S), WHILE PROPER CONTROL OF LOWERING ON THE FRONT HOIST ON THE 8000# MACHINES IS ACCOMPLISHED BY VALVE (U). THIS VALVE (U) WILL PROVIDE FREE FLOW IN THE HOISTING DIRECTION BUT WILL NOT OPEN IN THE LOWERING DIRECTION UNTIL APPROXIMATELY 40% OF LINE PRESSURE IS AVAILABLE THROUGH THE PILOT CONNECTION FROM THE LOWERING END OF THE CYLINDER (W). ON ALL THE MACHINES THE REAR HOIST LOWERS AT THE FREE FLOW RATE. SPEED OF FRONT AND REAR HOISTS IS REGULATED BY FLOW CONTROL VALVES (J) AND (K).
MAXIMUM PRESSURES OF PUMPS (B), (C), AND (D) ARE REGULATED THROUGH THE SETTING OF RELIEF VALVES (F), (G) AND (H).
SCHEMATIC HOIST LINKAGE
FRONT HOIST CYLINDER
REAR HOIST CYLINDERS
SHEAVES
CABLES
LOAD
OPERATOR RIDES WITH TROLLEY
FRONT HOIST CYLINDER
REAR HOIST CYLINDERS
ROTARY GRIP CYLINDER
GRIP RELEASE
HOSE
RELIEF VALVE (250 PSI APPROX.)
NEEDLE VALVE (4000# MACHINE ONLY)
CHECK VALVE (4000# MACHINE ONLY)
PILOT OPERATED CHECK VALVE (8000# MACHINE ONLY)
FRONT LEVEL VALVE
HOIST VALVES
REAR LEVEL VALVE
GRIP VALVE
MAN
HOIST
LOWER
LINK
GRIP
RELEASE
CHECK VALVE
FLOW CONTROL VALVE V (PC)
UNLOADING VALVE (CLOSED BELOW 150 PSI PILOT PRESSURE)
RELIEF VALVE (650 PSI APPROX)
RELIEF VALVE (600 PSI APPROX)
RELIEF VALVE (1000PSI APPROX)
ALL PIPE COLD DRAWN SEAMLESS TUBING EXCEPT AS NOTED
NOTE: PUMPS, MOTOR, AND CYLINDERS ON 4000# MACHINES SLIGHTLY SMALLER THAN SHOWN
PF 36.8 GPM
ELECT MOTOR 25 HP
PF 36.8 GPM
PF 3.5 GPM
120 GALLON TANK

lic designs and problems, no attempt will be made to cover other aspects, such as mechanical, structural, and electrical components of the machines.

Incidentally, and possibly most importantly, the writer wishes to emphasize that he poses not as an expert on hydraulic design, but merely as a maintenance man who has had a hand in correcting hydraulic problems the "hard" way.

The original hydraulic system on the six open hearth charging machines to be considered in detail is shown in Figure 1. Note that the hoist linkage is such that the net force on the cylinders is normally always "down" regardless of load conditions. The clamp holds the charging box in a firm friction grip without resort to any lockrod.

The main oil flow routes have been shown heavier than standard on all of these diagrams for the sake of clarity, while pilot and drain lines have been shown lighter or dotted.

As explained on the drawing, this is a two-pump system. Such a system utilizes a large "volume" pump to supply the great amount of oil required for rapid motion of the hoist and clamp, while a much smaller "pressure" pump is used to maintain system pressure and pilot pressure after the working strokes have been completed.

It will be noted that with directional valve (N) centered, the output of both pumps (B) and (C) is unloaded directly to the tank, and power input to the pumps is low. However, at the end of a power stroke, as when the machine is holding a box, valve (N) will not be bypassing any oil and means must therefore be provided to unload the "volume" pump (B). As shown, this unloading is accomplished by valves (K), (J) and (E).

The functions of the other valves and accumulators are clearly described on the drawing. Incidentally, the pilot connection from valve (R) was moved as shown when it was discovered during the first few hours of operation that when the system pressure dipped at the initiation of a "down" motion, the valve (R) would slam shut due to reduced pilot pressure. The resulting hydraulic shock broke connections between (R) and cylinders (S) (S) until the pilot connection was moved to a point as shown where pressure trapped between accumulator (Q) and check valve (W) remains essentially constant during hoist motions.

Note that since the operator does not ride with the trolley, the control of the directional valves (M) and (N) must be accomplished electrically with solenoids.

Note also that the pumps, motors, and all valves are assembled as an integral unit on the oil reservoir. The only external portions of the system are the three cylinders, the big accumulator, and the connecting piping.

The hoist cylinders (S) (S) are trunnion mounted, with swivel hydraulic connections at the trunnions. The rams are chromium plated for minimum wear of the multiple "V"-type ram packing. Adjustable hydraulic cushions provide smooth deceleration in both directions. The accumulator (L) is mounted vertically in an extremely inaccessible position. The clamp cylinder (T) is similar to the hoist cylinders in construction but is not trunnion mounted.

The external connecting piping was all 2⅜-in. outside diam steel tubing with bolted flange joints fitted with synthetic rubber "O" rings, with the exception of short flexible links of 1½-in. high pressure hose in the hoist and clamp lines.

The four directional control solenoids are integral with the directional valve units and are connected to the control master switches through multi-conductor control cables on spring-type reels.

Considering briefly the three axle plant manipulators, refer to Figure 2. While the drawing is essentially self-explanatory, two features might be pointed out. First, since these machines must grip a variety of sizes of forgings, the travel of the clamp piston is relatively long. To provide rapid clamping, the output of both pumps (C) and (D) is used for clamping, after which pump (D) alone maintains clamping pressure while pump (C) is then used for hoisting. Secondly, note the two different lowering schemes used on the front hoist on the 4000 and 8000-lb machines.

The axle plant furnace charger is shown on Figure 3. The outstanding feature of this machine is its simplicity, due mainly to the pressure-compensated variable displacement pumps and the "gravity" return type of hoist linkage. This hoist linkage is not suitable to open hearth chargers or similar machines where occasionally it is desirable to resist a negative load on the peel.

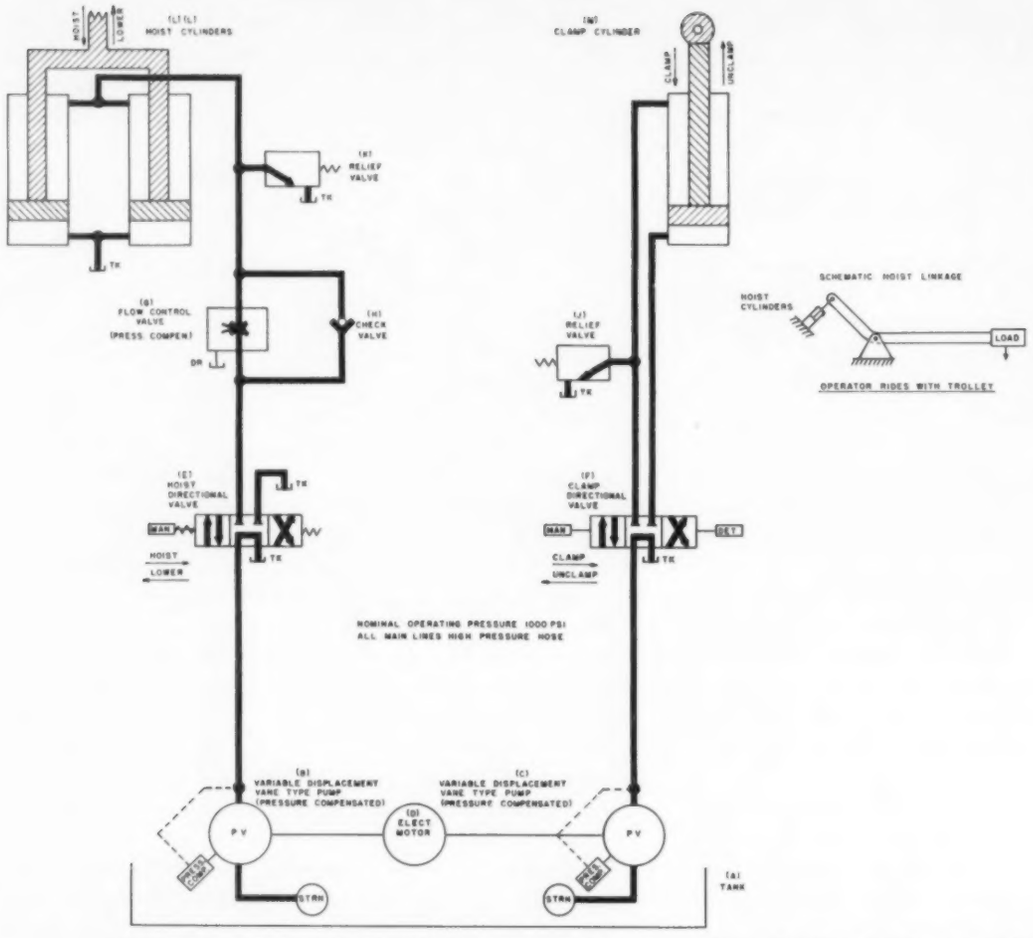
Figure 4 shows the plate mill furnace charging machine scheme. This was adapted from Figure 1 to provide interchangeability of spare parts. The essential difference is in the idle-condition, unloading scheme. Since it is necessary on this type of machine to operate the hoist and clamp independently, an open-center valve could not be used for (N) as in Figure 1. Accordingly, valves (X) and (Y) were added which unload the system after a short time interval in the idle condition. Otherwise, the scheme is a duplicate of Figure 1.

The system of two new open hearth chargers at a different plant is shown on Figure 5. This is a two-pump system with manually operated pilot directional valves (S) and (T). Note the pump unloading scheme. Note also the unbalanced peel arrangement which necessitates special hoist control valves (U) and (V) in both hoisting and lowering directions.

A one-pump system is used on two machines at another plant as shown on Figure 6. Note the simplicity of this arrangement due to the one-pump system and manual directional valves. However, the unbalanced peel arrangement on this machine also necessitates the inclusion of hoist control valves (J) and (K) in both hoisting and lowering directions.

Still another plant has one machine with the extremely simple scheme shown on Figure 7. With the manual directional valves the operators find it possible to control the hoist satisfactorily without the necessity of any counter-balance or flow control valves in the hoist circuit.

All of these schemes involve only the hoist and clamp motions. Some of the Canadian steel people tell us that they have machines with hydraulic peel rotation which work quite satisfactorily, but there is no hydraulic rota-



DESCRIPTION

IN THE IDLE CONDITION, WITH BOTH DIRECTIONAL VALVES CENTERED, DELIVERY OF PUMP (B) IS THROUGH VALVE (E) TO TANK AND DELIVERY OF PUMP (C) IS THROUGH VALVE (F) TO TANK.

MANUAL SHIFTING OF CLAMP VALVE (F) IN "CLAMP" DIRECTION DIRECTS OIL FROM PUMP (C) THROUGH VALVE (F) TO THE TOP OF CLAMP CYLINDER (M). OIL FROM BOTTOM OF CYLINDER (M) RETURNS TO TANK THROUGH VALVE (F). MAXIMUM CLAMPING PRESSURE IS LIMITED BY RELIEF VALVE (J), ALTHOUGH UNDER ORDINARY CIRCUMSTANCES MAXIMUM OPERATING PRESSURE IS REGULATED BY THE PRESSURE COMPENSATOR ON PUMP (C) WHICH SHORT-STROKES THE PUMP AUTOMATICALLY AT THE PRESET OPERATING POINT.

MANUAL SHIFTING OF CLAMP VALVE (F) IN THE "UNCLAMP" DIRECTION DIRECTS OIL FROM PUMP (C) THROUGH VALVE (F) TO THE BOTTOM OF CLAMP CYLINDER (M), WHILE OIL FROM THE TOP OF THE CYLINDER RETURNS TO TANK THROUGH VALVE (F). SINCE THE PISTON CAN "BOTTOM" IN THIS DIRECTION THERE IS NO RELIEF VALVE TO LIMIT THE UNCLAMPING PRESSURE.

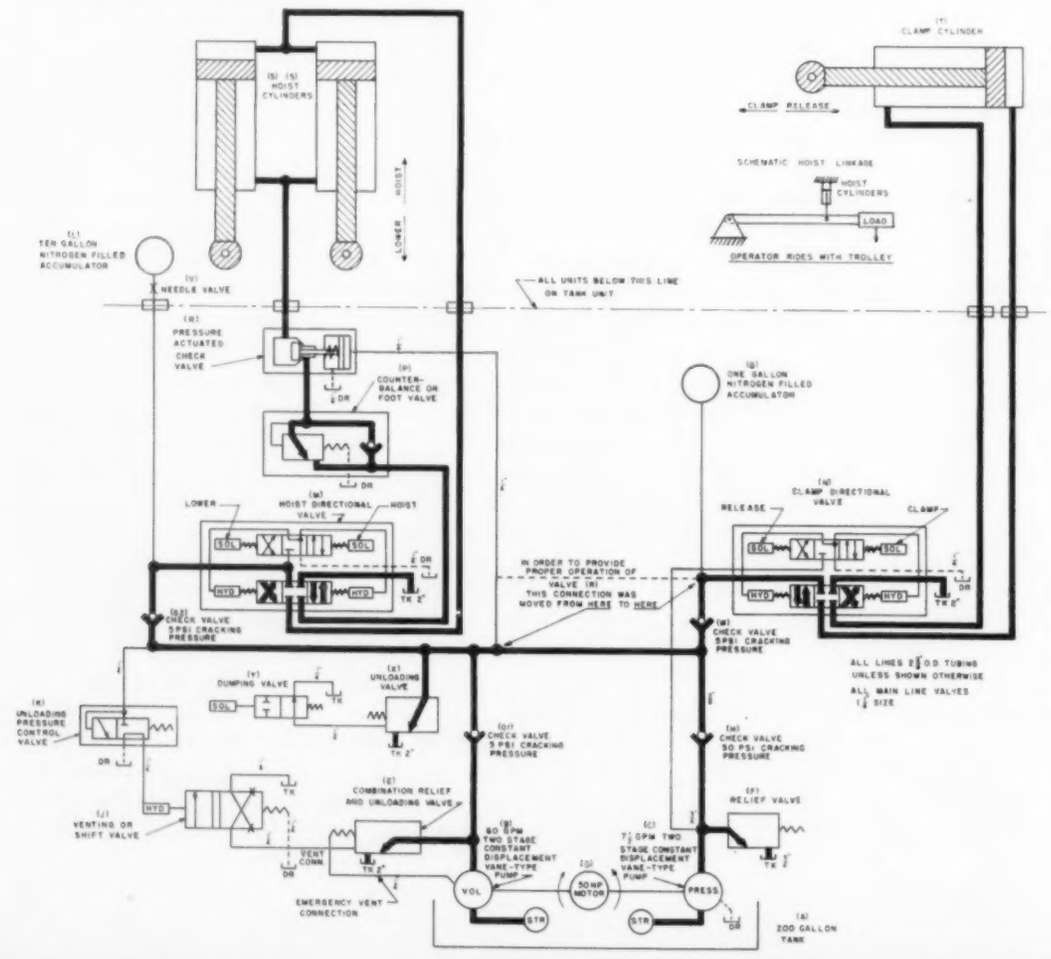
MANUAL SHIFTING OF THE HOIST VALVE (E) IN "HOIST" DIRECTION DIRECTS OIL FROM PUMP (B) THROUGH VALVE (E) AND CHECK VALVE (H) TO THE TOP OF HOIST CYLINDERS (L) (L). OIL FROM THE BOTTOM OF CYLINDERS (L) (L) RETURNS TO TANK DIRECTLY. RELIEF VALVE (K) LIMITS MAXIMUM LOAD LIFTED IN THE EVENT THAT PRESSURE COMPENSATOR ON PUMP (B) MALFUNCTIONS OR IS SET TOO HIGH.

MANUAL SHIFTING OF THE HOIST VALVE (E) IN THE "LOWER" DIRECTION CONNECTS THE CYLINDER LINE DIRECTLY TO THE TANK AS SHOWN IN THE SCHEMATIC LINKAGE DIAGRAM. THE EFFECT OF THE LOAD IS TO KEEP PRESSURE ON THE OIL IN THE TOP OF CYLINDERS (L) (L) AT ALL TIMES, REGARDLESS OF THE MAGNITUDE OF THE LOAD. WITH THE VALVE (E) IN THE "LOWER" DIRECTION, OIL FROM THE TOP OF CYLINDERS (L) (L) PASSES AT A REGULATED RATE THROUGH FLOW CONTROL VALVE (G), THROUGH VALVE (E) TO THE TANK. MAXIMUM LOWERING SPEED IS LIMITED BY SETTING OF FLOW CONTROL VALVE (G) AS PISTONS IN CYLINDERS (L) (L) RISE, OIL IS DRAWN INTO THE BOTTOM OF THE CYLINDERS DIRECTLY FROM THE TANK. NOTE THAT WHEN VALVE (E) IS IN THE "LOWER" DIRECTION, PUMP (B) IS UNLOADED DIRECTLY TO TANK EXACTLY AS IN THE "NEUTRAL" CONDITION.

NOTE THAT WITH THIS "GRAVITY RETURN" HOIST SCHEME THE HOIST CYLINDER OFFERS NO REACTION TO A REVERSAL OF LOAD OR THE BOOM. ON THIS PARTICULAR APPLICATION THIS FEATURE IS NOT OBJECTIONABLE, AS REVERSE LOADS ARE NEVER ENCOUNTERED.

Figure 3 — Hydraulic circuit for hoist and clamp motions of axle plant furnace charging machine.

Figure 4 — This two-pump hydraulic circuit was adapted for use on hoist and clamp motions of a plate mill furnace charging machine.



DESCRIPTION

IN THE IDLE CONDITION, WITH ALL SOLENOIDS DE-ENERGIZED, THE DELIVERY OF VOLUME PUMP (B) IS UNLOADED TO TANK THROUGH VALVES (G) AND (X). THE DELIVERY OF PRESSURE PUMP (C) IS UNLOADED TO TANK THROUGH VALVES (W) AND (X).

WHEN EITHER THE CLAMP OR HOIST MASTER SWITCH IS OPERATED, THE TR RELAY IS ALSO PICKED UP, ENERGIZING THE DUMPING VALVE SOLENOID THE DUMPING VALVE (Y) SHIFTS TO BLOCK OFF THE VENT CONNECTION FROM UNLOADING VALVE (X), THEREBY CAUSING VALVE (X) TO CLOSE. THE CLOSING OF VALVE (X) BLOCKS THE FLOW TO THE TANK AND PROVIDES PRESSURE IN THE SYSTEM TO OPERATE EITHER THE HOIST OR CLAMP.

THE TR RELAY PROVIDES A 30 SECOND TIME DELAY BEFORE THE SYSTEM UNLOADS AFTER EITHER MASTER SWITCH HAS BEEN CENTERED. THIS PROVIDES MORE RAPID RESPONSE WHEN THE MACHINE IS MAKING A NUMBER OF CONSECUTIVE MOVEMENTS.

WHEN VALVE (N) HAS SHIFTED AND PISTON IN CYLINDER (T) HAS REACHED THE END OF IT'S STROKE, THE PRESSURE IN THE SYSTEM WILL RISE UNTIL IT REACHES THE ADJUSTED SETTING OF VALVE (K) WHICH SHIFTS TO DIRECT OIL TO SHIFT VALVE (J). VALVE (J) THEN SHIFTS TO VENT UNLOADING VALVE (X) WHICH SHIFTS TO UNLOAD VOLUME PUMP (B). PRESSURE IS THEN MAINTAINED IN THE SYSTEM THROUGH DELIVERY OF PRESSURE PUMP (C) ONLY A SIMILAR SEQUENCE TAKES PLACE WHEN HOIST VALVE (N) IS OPERATED.

VALVES (N) AND (O) PROVIDE DIRECTIONAL CONTROL FOR HOIST CYLINDERS AND CLAMP CYLINDER RESPECTIVELY.

VALVE (P) ACTS AS A COUNTERBALANCE VALVE FOR HOIST CYLINDERS (S) (S).

PRESSURE ACTUATED CHECK VALVE (R) WILL CLOSE IF PRESSURE IS LOST ON THE SYSTEM AND WILL THEREBY PREVENT DROPPING OF THE PEEL EVEN IF VALVE (P) SHOULD JAM OPEN OR BE SET TOO LOW.

ACCUMULATOR (L) IS TO MINIMIZE HYDRAULIC SHOCK WHILE ACCUMULATOR (Q) RETAINS CLAMP PRESSURE DURING HOIST OPERATION AND ASSURES PROPER RETENTION OF PILOT PRESSURE ON THE PRESSURE ACTUATED CHECK VALVE (R).

MAXIMUM OPERATING PRESSURE IS ADJUSTED THROUGH VALVE (P) WHICH ALSO PROVIDES OVERLOAD PROTECTION. WHILE UNLOADING PRESSURE IS ADJUSTED THROUGH VALVE (K).

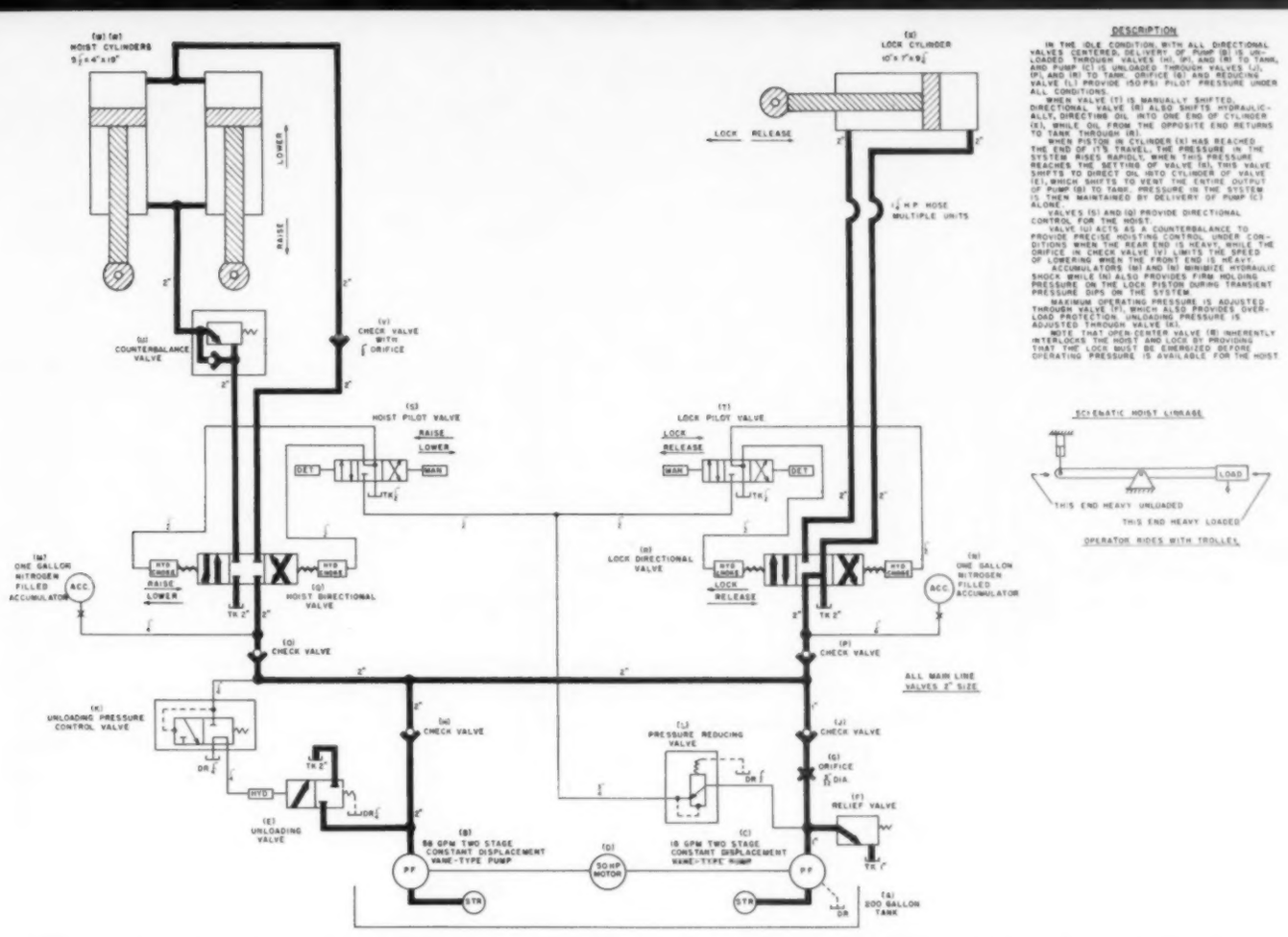
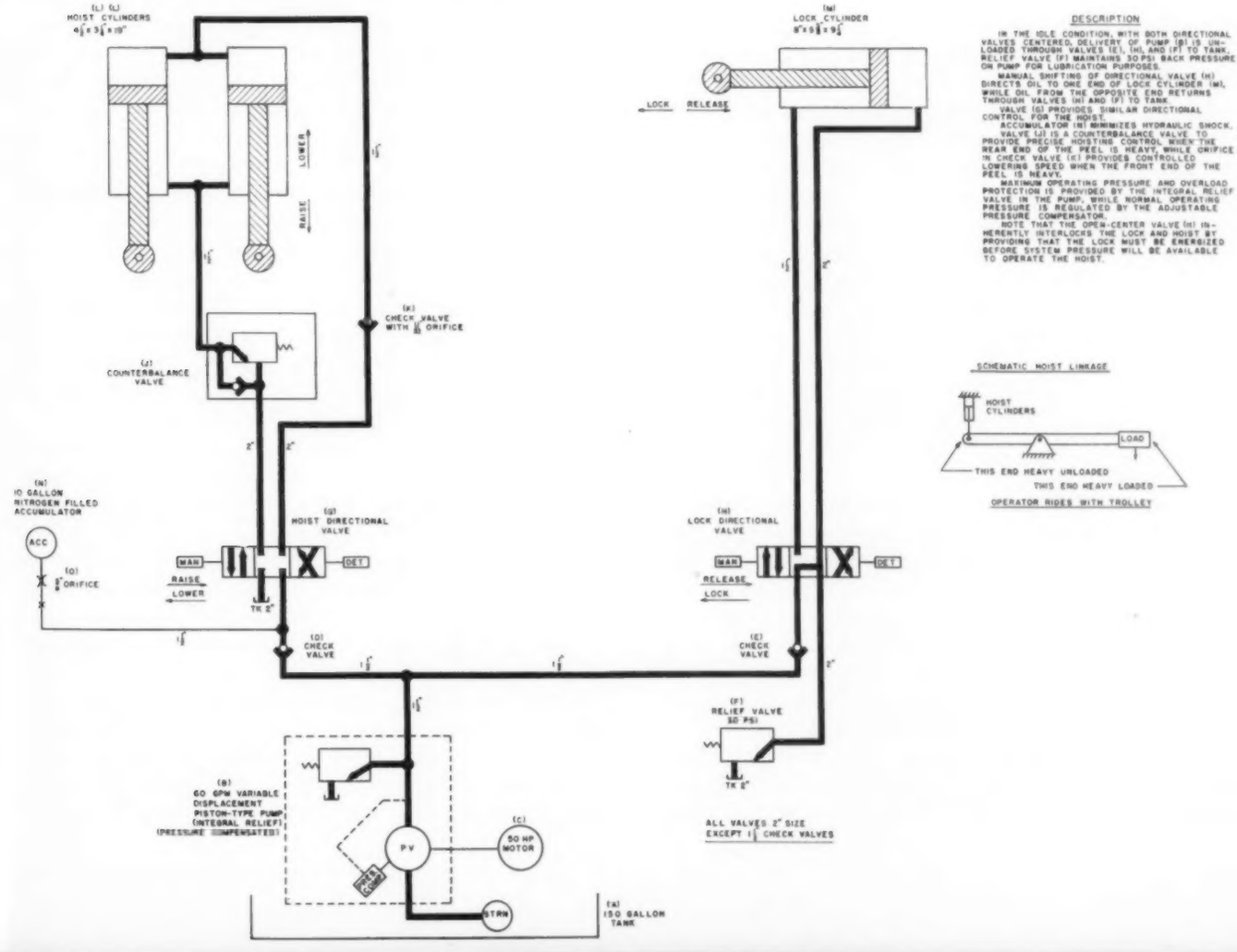

DESCRIPTION
IN THE IDLE CONDITION, WITH ALL DIRECTIONAL VALVES CENTERED, DELIVERY OF PUMP (B) IS UNLOADED THROUGH VALVES (H), (P), AND (R) TO TANK, AND PUMP (C) IS UNLOADED THROUGH VALVES (J), (P), AND (R) TO TANK. ORIFICE (G) AND REDUCING VALVE (L) PROVIDE 150 PSI PILOT PRESSURE UNDER ALL CONDITIONS.
WHEN VALVE (T) IS MANUALLY SHIFTED, DIRECTIONAL VALVE (R) ALSO SHIFTS HYDRAULICALLY, DIRECTING OIL INTO ONE END OF CYLINDER (X), WHILE OIL FROM THE OPPOSITE END RETURNS TO TANK THROUGH (R).
WHEN PISTON IN CYLINDER (X) HAS REACHED THE END OF ITS TRAVEL, THE PRESSURE IN THE SYSTEM RISES RAPIDLY. WHEN THIS PRESSURE REACHES THE SETTING OF VALVE (N), THIS VALVE SHIFTS TO DIRECT OIL INTO CYLINDER OF VALVE (E), WHICH SHIFTS TO VENT THE ENTIRE OUTPUT OF PUMP (B) TO TANK. PRESSURE IN THE SYSTEM IS THEN MAINTAINED BY DELIVERY OF PUMP (C) ALONE.
VALVES (S) AND (Q) PROVIDE DIRECTIONAL CONTROL FOR THE HOIST.
VALVE (J) ACTS AS A COUNTERBALANCE TO PROVIDE PRECISE HOISTING CONTROL UNDER CONDITIONS WHEN THE REAR END IS HEAVY, WHILE THE ORIFICE IN CHECK VALVE (V) LIMITS THE SPEED OF LOWERING WHEN THE FRONT END IS HEAVY.
ACCUMULATORS (B) AND (N) MINIMIZE HYDRAULIC SHOCK WHILE (N) ALSO PROVIDES FIRM HOLDING PRESSURE ON THE LOCK PISTON DURING TRANSIENT PRESSURE DIPS ON THE SYSTEM.
MAXIMUM OPERATING PRESSURE IS ADJUSTED THROUGH VALVE (F), WHICH ALSO PROVIDES OVERLOAD PROTECTION. UNLOADING PRESSURE IS ADJUSTED THROUGH VALVE (K).
NOTE THAT OPEN-CENTER VALVE (R) INHERENTLY INTERLOCKS THE HOIST AND LOCK BY PROVIDING THAT THE LOCK MUST BE ENERGIZED BEFORE OPERATING PRESSURE IS AVAILABLE FOR THE HOIST
SCHEMATIC HOIST LINKAGE
LOAD
THIS END HEAVY UNLOADED
THIS END HEAVY LOADED
OPERATOR RIDES WITH TROLLEY
(g) (e) HOIST CYLINDERS 9" x 4" x 19"
LOWER
RAISE
(x) LOCK CYLINDER 10" x 7" x 9"
LOCK
RELEASE
2" I.D. H.P. HOSE MULTIPLE UNITS
(J) COUNTERBALANCE VALVE
(V) CHECK VALVE WITH 1/8" ORIFICE
(S) HOIST PILOT VALVE
RAISE
LOWER
DET
MAN
(T) LOCK PILOT VALVE
LOCK
RELEASE
(N) ONE GALLON NITROGEN FILLED ACCUMULATOR
ACC.
HYD CLOSE
HYD LOWER
(Q) HOIST DIRECTIONAL VALVE
(R) LOCK DIRECTIONAL VALVE
(B) ONE GALLON NITROGEN FILLED ACCUMULATOR
TK 2"
(O) CHECK VALVE
(P) CHECK VALVE
ALL MAIN LINE VALVES 2" SIZE
(K) UNLOADING PRESSURE CONTROL VALVE
DR
(W) CHECK VALVE
(L) PRESSURE REDUCING VALVE
(Z) CHECK VALVE
(G) ORIFICE 1/8" DIA.
(F) RELIEF VALVE
HYD
(E) UNLOADING VALVE
(B) 88 GPM TWO STAGE CONSTANT DISPLACEMENT VANE-TYPE PUMP
(D) 50 HP MOTOR
(C) 18 GPM TWO STAGE CONSTANT DISPLACEMENT VANE-TYPE PUMP
PF
STR
(A) 200 GALLON TANK

Figure 5 — Two-pump hydraulic circuit is shown for hoist and lock motions of low type open hearth charging machines.

Figure 6 — Schematic diagram shows a one-pump hydraulic circuit for the hoist and lock motions of a low type open hearth charging machine.


DESCRIPTION
IN THE IDLE CONDITION, WITH BOTH DIRECTIONAL VALVES CENTERED, DELIVERY OF PUMP (B) IS UNLOADED THROUGH VALVES (E), (H), AND (F) TO TANK. RELIEF VALVE (F) MAINTAINS 30 PSI BACK PRESSURE ON PUMP FOR LUBRICATION PURPOSES.
MANUAL SHIFTING OF DIRECTIONAL VALVE (H) DIRECTS OIL TO ONE END OF LOCK CYLINDER (W), WHILE OIL FROM THE OPPOSITE END RETURNS THROUGH VALVES (H) AND (F) TO TANK.
VALVE (G) PROVIDES SIMILAR DIRECTIONAL CONTROL FOR THE HOIST.
ACCUMULATOR (N) MINIMIZES HYDRAULIC SHOCK.
VALVE (J) IS A COUNTERBALANCE VALVE TO PROVIDE PRECISE HOISTING CONTROL WHEN THE REAR END OF THE PEEL IS HEAVY, WHILE ORIFICE IN CHECK VALVE (K) PROVIDES CONTROLLED LOWERING SPEED WHEN THE FRONT END OF THE PEEL IS HEAVY.
MAXIMUM OPERATING PRESSURE AND OVERLOAD PROTECTION IS PROVIDED BY THE INTEGRAL RELIEF VALVE IN THE PUMP, WHILE NORMAL OPERATING PRESSURE IS REGULATED BY THE ADJUSTABLE PRESSURE COMPENSATOR.
NOTE THAT THE OPEN-CENTER VALVE (H) INHERENTLY INTERLOCKS THE LOCK AND HOIST BY PROVIDING THAT THE LOCK MUST BE ENERGIZED BEFORE SYSTEM PRESSURE WILL BE AVAILABLE TO OPERATE THE HOIST.
SCHEMATIC HOIST LINKAGE
HOIST CYLINDERS
LOAD
THIS END HEAVY UNLOADED
THIS END HEAVY LOADED
OPERATOR RIDES WITH TROLLEY
(L) (L) HOIST CYLINDERS 4" x 3" x 19"
LOWER
RAISE
(W) LOCK CYLINDER 8" x 5" x 9"
LOCK
RELEASE
(K) CHECK VALVE WITH 1/8" ORIFICE
(J) COUNTERBALANCE VALVE
(N) 10 GALLON NITROGEN FILLED ACCUMULATOR
ACC.
(G) HOIST DIRECTIONAL VALVE
(H) LOCK DIRECTIONAL VALVE
MAN
DET
RAISE
LOWER
RELEASE
LOCK
(Q) 1/8" ORIFICE
TK 2"
(D) CHECK VALVE
(E) CHECK VALVE
(F) RELIEF VALVE 30 PSI
(B) 60 GPM VARIABLE DISPLACEMENT PISTON-TYPE PUMP (INTEGRAL RELIEF) (PRESSURE COMPENSATED)
PV
(C) 50 HP MOTOR
CASE DRAIN
STR
(A) 150 GALLON TANK
ALL VALVES 2" SIZE EXCEPT 1 1/2" CHECK VALVES

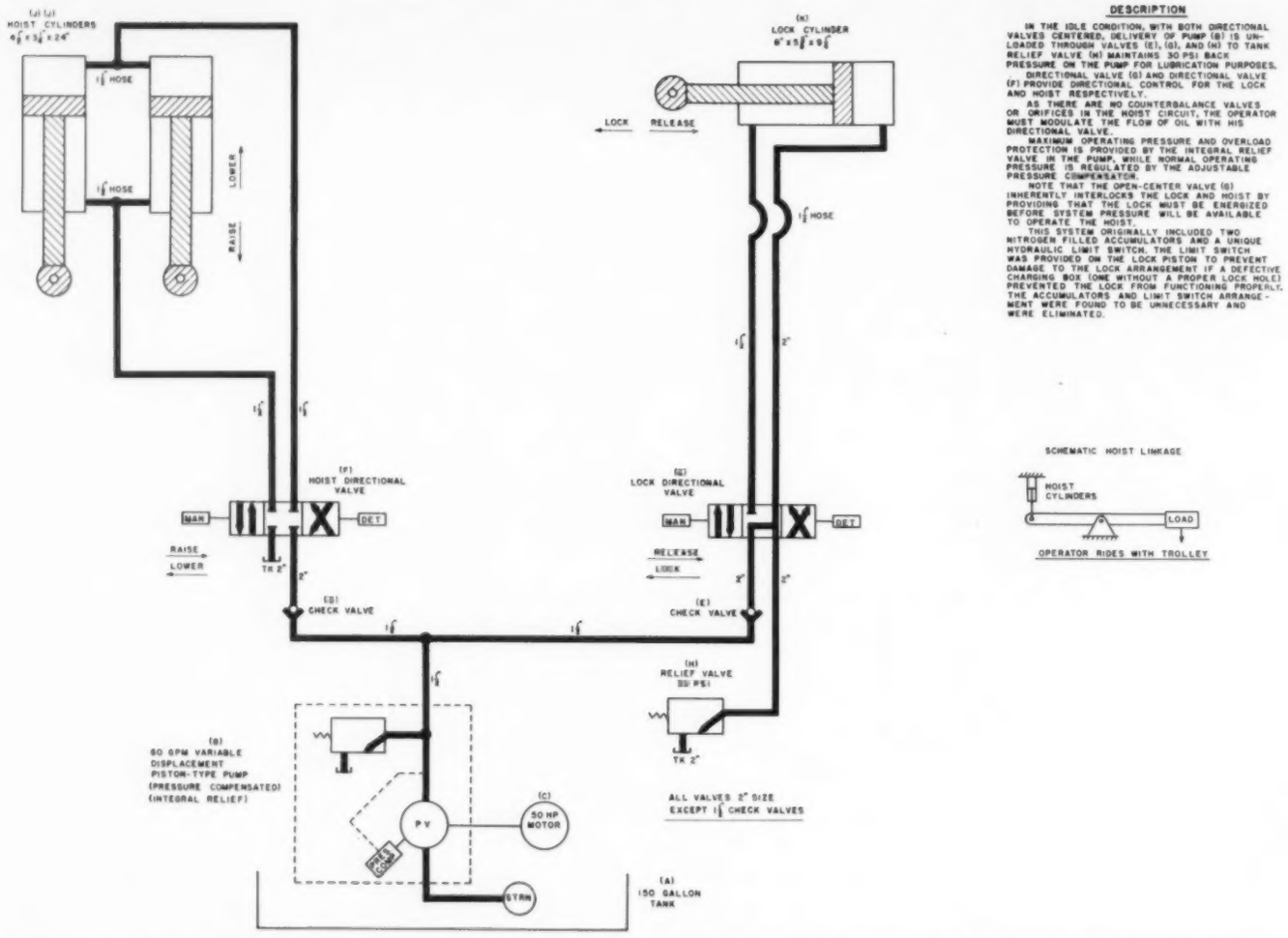

DESCRIPTION
IN THE IDLE CONDITION, WITH BOTH DIRECTIONAL VALVES CENTERED, DELIVERY OF PUMP (B) IS UNLOADED THROUGH VALVES (E), (G), AND (H) TO TANK. RELIEF VALVE (H) MAINTAINS 30 PSI BACK PRESSURE ON THE PUMP FOR LUBRICATION PURPOSES.
DIRECTIONAL VALVE (G) AND DIRECTIONAL VALVE (F) PROVIDE DIRECTIONAL CONTROL FOR THE LOCK AND HOIST RESPECTIVELY.
AS THERE ARE NO COUNTERBALANCE VALVES OR ORIFICES IN THE HOIST CIRCUIT, THE OPERATOR MUST MODULATE THE FLOW OF OIL WITH HIS DIRECTIONAL VALVE.
MAXIMUM OPERATING PRESSURE AND OVERLOAD PROTECTION IS PROVIDED BY THE INTEGRAL RELIEF VALVE IN THE PUMP, WHILE NORMAL OPERATING PRESSURE IS REGULATED BY THE ADJUSTABLE PRESSURE COMPENSATOR.
NOTE THAT THE OPEN-CENTER VALVE (G) INHERENTLY INTERLOCKS THE LOCK AND HOIST BY PROVIDING THAT THE LOCK MUST BE ENERGIZED BEFORE SYSTEM PRESSURE WILL BE AVAILABLE TO OPERATE THE HOIST.
THIS SYSTEM ORIGINALLY INCLUDED TWO NITROGEN FILLED ACCUMULATORS AND A UNIQUE HYDRAULIC LIMIT SWITCH. THE LIMIT SWITCH WAS PROVIDED ON THE LOCK PISTON TO PREVENT DAMAGE TO THE LOCK ARRANGEMENT IF A DEFECTIVE CHARGING BOX (ONE WITHOUT A PROPER LOCK HOLE) PREVENTED THE LOCK FROM FUNCTIONING PROPERLY. THE ACCUMULATORS AND LIMIT SWITCH ARRANGEMENT WERE FOUND TO BE UNNECESSARY AND WERE ELIMINATED.
SCHEMATIC HOIST LINKAGE
HOIST CYLINDERS
LOAD
OPERATOR RIDES WITH TROLLEY
(d) (d) HOIST CYLINDERS 6" x 3½" x 24"
1½ HOSE
1½ HOSE
LOWER
RAISE
(k) LOCK CYLINDER 6" x 5" x 9"
LOCK
RELEASE
1½ HOSE
1½
2"
1½
1½
(F) HOIST DIRECTIONAL VALVE
MAN
DET
RAISE
LOWER
TK 2"
2"
(G) LOCK DIRECTIONAL VALVE
MAN
DET
RELEASE
LOCK
2"
2"
(D) CHECK VALVE
(E) CHECK VALVE
1½
1½
1½
(H) RELIEF VALVE 30 PSI
TK 2"
(B) 60 GPM VARIABLE DISPLACEMENT PISTON-TYPE PUMP (PRESSURE COMPENSATED) (INTEGRAL RELIEF)
PV
(C) 50 HP MOTOR
PRESS GAGE
STRN
(A) 150 GALLON TANK
ALL VALVES 2" SIZE EXCEPT 1½ CHECK VALVES

Figure 7 — Another one-pump hydraulic circuit for hoist and lock motions of a low type open hearth charging machine is given in this schematic sketch. This is somewhat simpler than the unit shown in Figure 6.

tion on any of the machines with which the writer is familiar.

Of the systems briefly described above, the scheme which was the least satisfactory from the start, involved the greatest number of machines, and constantly constituted the gravest threat to continued open hearth steel production, was that shown on Figure 1.

The hydraulic power units had been beautifully designed and constructed, with all of the valves on a vertical plate "panel" type of mounting. Piping joints and valve joints were bolted flanges with "O" rings. Pilot lines and drains were ¼-in. steel tubing with flared joints. Doubtless this type of construction had proven quite satisfactory on hydraulic presses and similar stationary applications. On a charging machine the situation was entirely different.

On the very first day of operation there were numerous pilot line failures. The ¼-in. steel tubes would split longitudinally, or break off, or pull out of the couplings. After several weeks of fruitless experimenting with various types of tubes and couplings, a tip from the mining people suggested the trial substitution of ¼-in. two-wire synthetic rubber hose, with a working pressure strength of 5000 psi and a bursting strength of 16,500 psi. With the working pressure of 1600 to 1700 psi, the hose worked well. However, it was still found that the ¼-in. tubes on the drain lines occasionally broke. It was reasoned that since pressure was practically atmospheric on these lines, the breakage had to be caused by shock or vibration. Accordingly, all of the ¼-in. drain tubes were replaced with ¼-in. hose similar to the pilot hoses, and the small-line troubles were over.

During this same period, there were several instances of check valve failure. The spring retainer consisted of a steel disc fitted with an "O" ring and secured in the valve body with a snap ring. Both the snap rings and discs failed repeatedly so the whole retained assembly was replaced with a very homely but effective threaded cap, similar to a common pipe cap. This corrected the trouble and the manufacturer subsequently revised his design to use a threaded retainer.

Another source of leakage which was immediately apparent and which has not been completely eliminated, has been the bolted "O" ring joints on the power units.

For example, the panel mounted valves depend upon the same bolts for mounting as for the hydraulic joint. Under mechanical shock, temperature changes, and vibration, these bolts stretch, causing microscopic parting of the joints. "O" rings, by their very nature will extrude into these small openings and will cut themselves into uselessness in a very short time. This condition has been corrected to a great extent by using triple-alloy bolts which will not stretch. Incidentally, various sheet gasketing schemes have also been tried

and found not equal to the strengthened "O" ring set-up.

On the flanged connections between valves, pumps, and the like, the same situation occurred to some extent, and has been greatly improved through the use of stronger bolts similar to those used on the valve connections.

The "volume" pumps were also a source of leaks due to lack of adequate sealing means on the adjustable heads. The manufacturer furnished redesigned heads with "O" ring seals which greatly improved this situation.

Another leak source was at the joints into the large and small accumulators. These were threaded connections in very inaccessible locations. No adequate way was found to eliminate this leakage except frequent inspection and tightening until later developments made it possible to eliminate the accumulators completely.

The greatest single early problem on these units not directly concerned with leakage was with the solenoids on the directional valves. In the first place, while they would have been readily accessible had the unit been placed in the open such as on top of a hydraulic press, the position of the units in the chargers made it extremely difficult to work on the solenoids. Moreover, the units could not be relocated due to the very restrictive clearance requirements effecting the chargers.

The coils started to fail during the first few hours of operation. Upon finding that most of the coils failed to ground rather than turn-to-turn, immediate steps were taken to increase the ground insulation. Over a long period, improvements were made to the ground insulation, lead insulation, and mechanical strength of the coils sufficient to greatly extend the life of the coils. These improvements are common-sense matters familiar to all experienced electrical shop people and will not warrant detailed coverage here. Various tests made with the cooperation of the coil manufacturer seemed to indicate at one time that high temperatures were responsible for the failures, but the experimental use of high-temperature insulations did not bear out this theory. However, subsequent developments did indicate that considerable coil mortality was caused by oil leakage into the coil chambers due to high-temperature failures of the "O" ring seals. This situation was improved at a later date.

In view of some of the high flash temperatures indicated on the trolleys of the chargers during the coil tests, however, it was felt that some steps should be taken to insulate the entire hydraulic power unit. Accordingly, one machine was fitted with a complete false bottom under the tank unit, and this space was filled with rock wool insulation. Furthermore, flame baffles were installed at the front of the high-type trolley to ward off the direct flames encountered during "blows" or "boils" on the furnaces. These measures had little effect on leaks or coil failures and no attempt was made to insulate the other five machines.

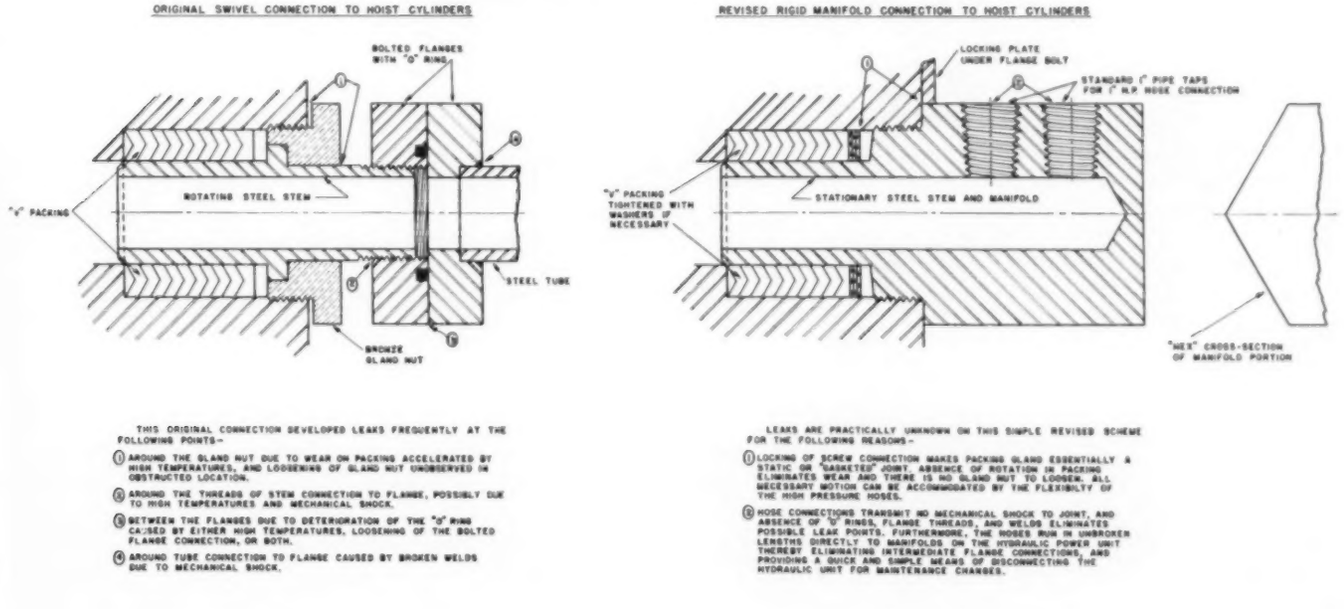
Not all of these early troubles were encountered on the hydraulic units alone. On the cylinders, the ram packing started to leak almost at once. Investigation disclosed that the "V" packing had alternate layers of metallic material which disintegrated rapidly and ruined the remaining non-metallic material. Substitution of an asebstos-base, 100 per cent non-metallic "V" packing provided much better packing life.

The swivel trunnion connections on the hoist cylinders were also quite troublesome. Figure 8 shows diagrammatically the original connection which had at least four leakage sources under conditions as described on the drawing. The revised manifold connection shown eliminated all of these leakage sources and permitted additional improvements to the connecting lines.

The further refinement made possible through the provision of the manifold connections on the cylinders was the complete elimination of solid piping between the cylinders and the power units. This elimination was highly desirable.

In the first place, there were two connections for the hoist, two for the clamp, and one for the big accumu-

Figure 8 — Hydraulic connections were redesigned to eliminate leakage points.


ORIGINAL SWIVEL CONNECTION TO HOIST CYLINDERS
BOLTED FLANGES WITH "O" RING
ROTATING STEEL STEM
"V" PACKING
STEEL TUBE
BRONZE GLAND NUT
THIS ORIGINAL CONNECTION DEVELOPED LEAKS FREQUENTLY AT THE FOLLOWING POINTS—
① AROUND THE GLAND NUT DUE TO WEAR ON PACKING ACCELERATED BY HIGH TEMPERATURES, AND LOOSENING OF GLAND NUT UNOBSERVED IN OBSTRUCTED LOCATION.
② AROUND THE THREADS OF STEM CONNECTION TO FLANGE, POSSIBLY DUE TO HIGH TEMPERATURES AND MECHANICAL SHOCK.
③ BETWEEN THE FLANGES DUE TO DETERIORATION OF THE "O" RING CAUSED BY EITHER HIGH TEMPERATURES, LOOSENING OF THE BOLTED FLANGE CONNECTION, OR BOTH.
④ AROUND TUBE CONNECTION TO FLANGE CAUSED BY BROKEN WELDS DUE TO MECHANICAL SHOCK.
REVISED RIGID MANIFOLD CONNECTION TO HOIST CYLINDERS
LOCKING PLATE UNDER FLANGE BOLT
STANDARD 1" PIPE TAPS FOR 1" H.P. HOSE CONNECTION
"V" PACKING TIGHTENED WITH WASHERS IF NECESSARY
STATIONARY STEEL STEM AND MANIFOLD
"HEX" CROSS-SECTION OF MANIFOLD PORTION
LEAKS ARE PRACTICALLY UNKNOWN ON THIS SIMPLE REVISED SCHEME FOR THE FOLLOWING REASONS—
① LOCKING OF SCREW CONNECTION MAKES PACKING GLAND ESSENTIALLY A STATIC OR "GASKETED" JOINT. ABSENCE OF ROTATION IN PACKING ELIMINATES WEAR AND THERE IS NO GLAND NUT TO LOOSEN. ALL NECESSARY MOTION CAN BE ACCOMMODATED BY THE FLEXIBILITY OF THE HIGH PRESSURE HOSES.
② HOSE CONNECTIONS TRANSMIT NO MECHANICAL SHOCK TO JOINT, AND ABSENCE OF "O" RINGS, FLANGE THREADS, AND WELDS ELIMINATES POSSIBLE LEAK POINTS. FURTHERMORE, THE HOSES RUN IN UNBROKEN LENGTHS DIRECTLY TO MANIFOLDS ON THE HYDRAULIC POWER UNIT THEREBY ELIMINATING INTERMEDIATE FLANGE CONNECTIONS, AND PROVIDING A QUICK AND SIMPLE MEANS OF DISCONNECTING THE HYDRAULIC UNIT FOR MAINTENANCE CHANGES.

lator. These connections were all made with bolted flanges, fitted with "O" rings on 2⅜-in. outside diam steel tubing. Due to the shock and vibration common to all charging machines, these joints could not be kept tight and leaked continually. Furthermore, since this piping was of necessity exposed on the top of the units, the occasional and unavoidable "wrecks" with the overhead hot metal cranes always left a mass of bent and twisted piping which had to be straightened out before the machine could operate. This was always a time-consuming process.

Lastly, when it became necessary to replace a power unit for maintenance purposes, the badly mauled piping would never fit and usually had to be jacked into place.

Experience with the original 1½-in. high pressure hose links in this rigid piping had been unsatisfactory. The hose had a maximum working pressure rating of 1500 psi and a bursting strength of about 6000 psi. At the working pressure of 1700 psi these hoses did not hold up. Early in the game, the 1½-in. hoses were replaced with dual links of 1-in. hose as a temporary expedient. The 1-in. hoses had a working rating of 2250 psi and a bursting strength of 7500 psi.

Accordingly, when the cylinder manifolds were redesigned, it was decided to put four-hose manifolds on the hoist outlets, and two-hose manifolds on the clamp outlets, and run the multiple 1-in. hose lines directly from the power units to the cylinders, thereby eliminating all solid piping. It was further reasoned that the "accumulator" action of the multiple hoist hoses would eliminate the need for the large accumulator and its connections, so this connection was not provided.

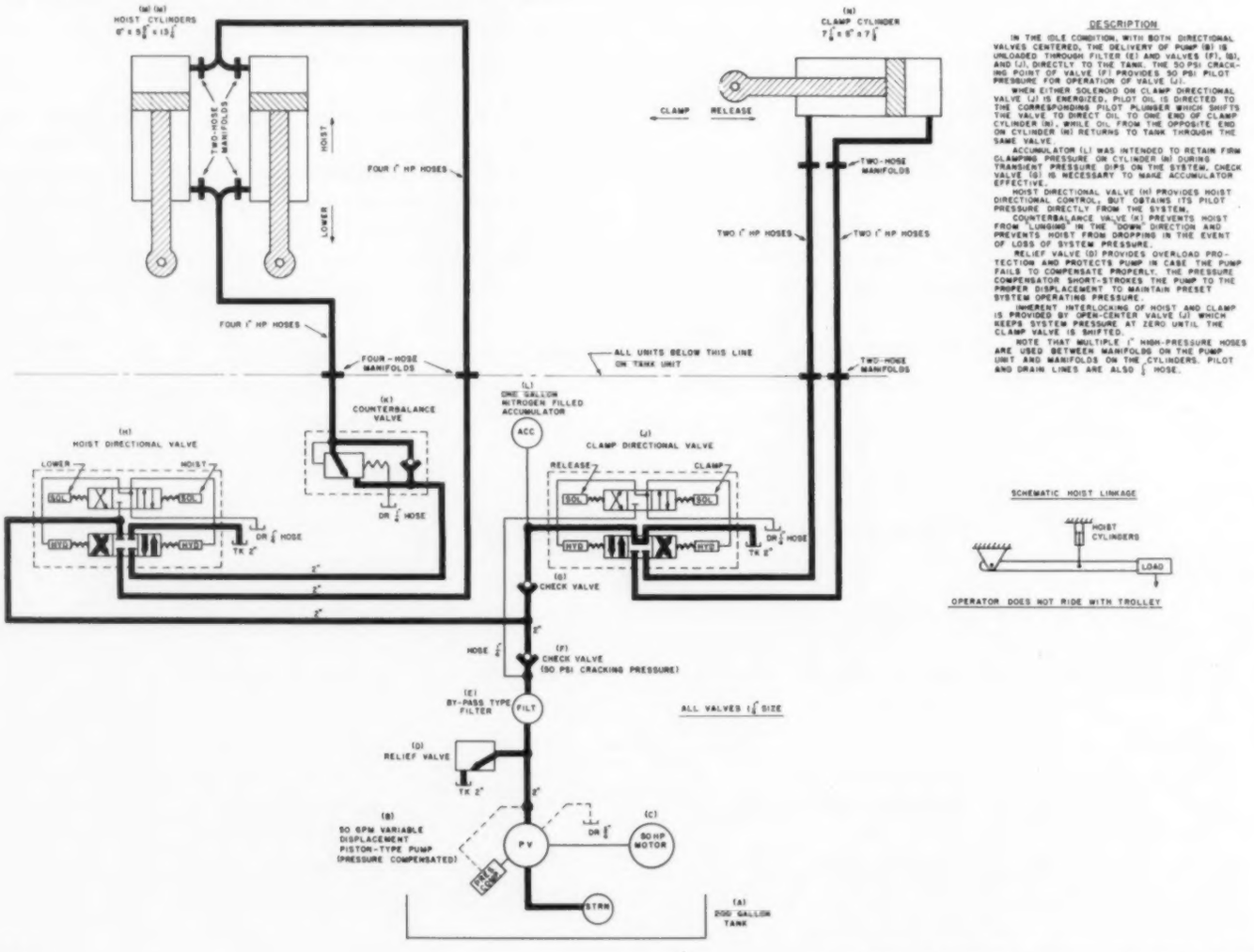
Subsequent operation of the hose-equipped machine was so successful that provisions were made to convert all six machines to hose as rapidly as operations would permit. The slight reduction in capacity from single 1½-in. hose to dual 1-in. hoses was not noticeable.

Incidentally, the substitution of the hose connections for rigid piping reduced the time required to change a power unit from approximately 16 to less than 3½ hours.

With the original remedial steps completed, the machines performed fairly satisfactorily until the first prolonged hot weather operations were encountered, at which time some of the old original troubles and a few new ones presented themselves.

The first indications were higher oil temperatures and increased leakage through "O" ring joints. Then it was found that the pressure pumps were unable to maintain normal system pressure. The increased "O" ring leakage permitted additional oil to escape into the

Figure 9 — Schematic diagram shows first experimental one-pump system for hydraulic circuit on hoist and clamp motions of high type open hearth charging machine.



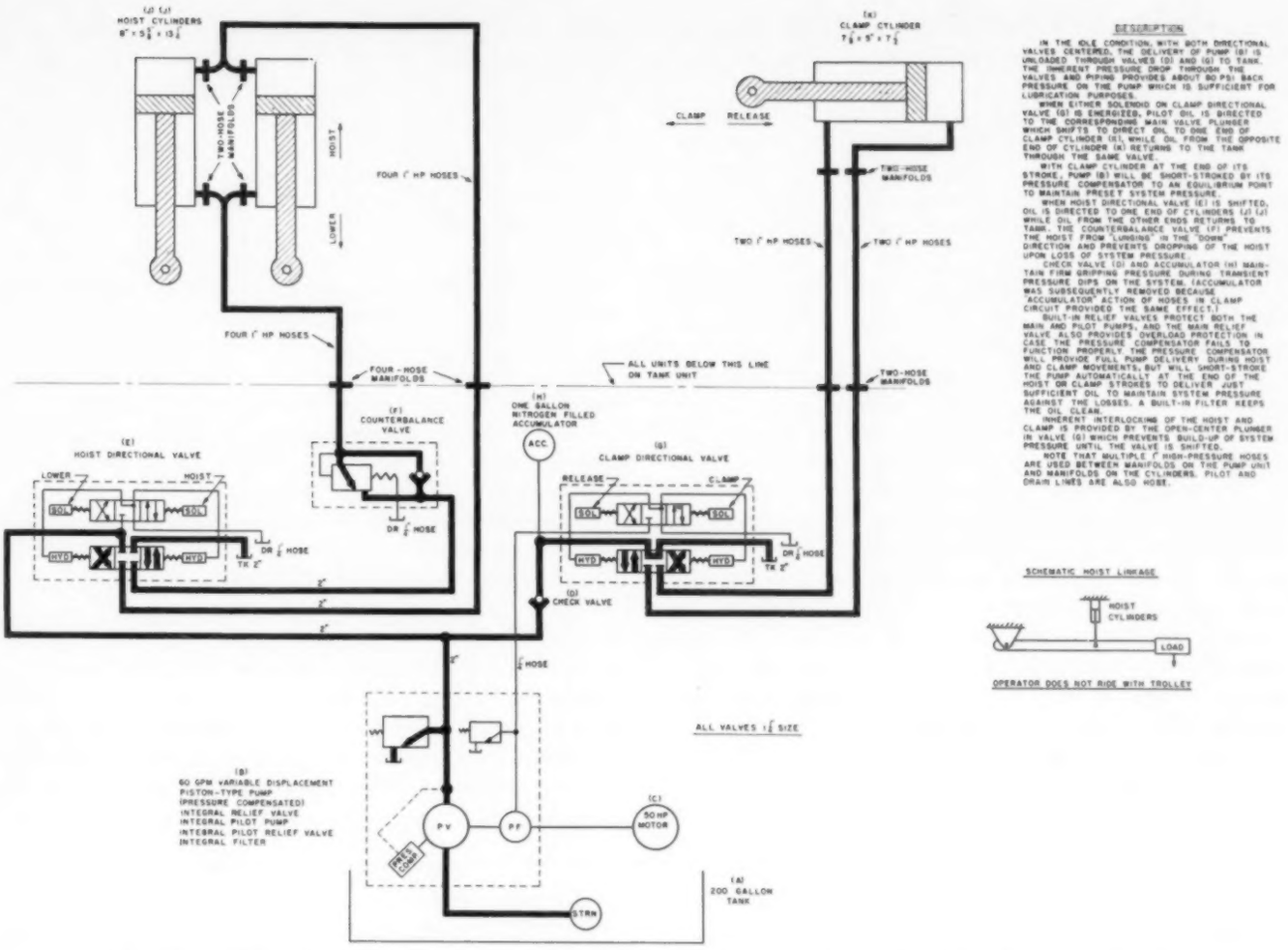


Figure 10 — This scheme is an improvement over the one shown in Figure 9 and has fewer components.

solenoid chambers and solenoid coil failures skyrocketed. Finally, the pressure pumps themselves started to fail.

The first impulse was to install larger pressure pumps, so experiment was made with gear pumps of about 12-gpm capacity, and vane pumps of about 13-gpm capacity. All of the experimental pumps would run at 1700 psi for 24 to 36 hours, and then they would drop down to 1000 psi or less.

Finally, a series of accurate temperature tests were run and it was discovered that oil temperatures in the tank were running as high as 230 F on machines where the ambients did not exceed 120 F. Quick reference to an ASTM viscosity-temperature chart revealed that a 300 SSU oil of the type being used dropped to about 47 SSU at 230 F. Since the tank temperature was obviously the lowest temperature in the oil system it was reasonable to assume that the temperatures in the pumps were at least 275 to 280 F which would put the oil at a viscosity below the critical point of 40 SSU and into the danger zone in which viscosity is so low that practically no lubricity exists.

Moreover, the pump manufacturer recommended a maximum operating temperature of not over 155 F and the "O" rings were not recommended for temperatures above 200 F.

Obviously, the answer was to provide heat exchangers to hold the oil temperature within the recommended range of 135 to 155 F. To find sufficient space to install such heat exchangers seemed hopeless in view of the critical clearance condition and the compact arrangement of the trolleys, but space was finally found on the cab side of the trolleys for three 6-ft lengths of 1¼-in. finned steel radiator tubing.

Small gear-pumps driven by 1-hp, d-c motors and with a capacity of approximately 17.5 gpm were installed to circulate the oil from the hottest part of the tank through the three radiator tubes in series and back into the cool end of the tank. This pump circulates all of the oil in the tank once every 12 minutes or about five times per hour.

The cramped conditions prevented the installation of fans on the trolley to ride with the radiators, but small centrifugal blowers driven by 1½-hp, d-c motors with a capacity of approximately 2300 cfm at zero back pressure were installed on the bridge and ducted in a manner to direct the air stream across the radiators when the trolleys were in the idle position against the cage-end bumpers.

While it was difficult to predict exactly how these heat exchangers would function under the extremely severe conditions, it was felt reasonably certain that they would dispell at least 100,000 Btu per hour, or about 40-hphr per hour. Inasmuch as it was assumed that the losses in the system would not average over 10 hphr, it was believed that the other 30 hphr per hour

would take care of the heat picked up, radiation from the furnaces, from furnace boils and blows, and miscellaneous sources.

Actually, the heat exchangers have held the tank temperatures down to between 150 and 160 F on days when the ambients approached 120 F, and on the usual warm days when the ambients run around 100 F, the tank temperatures do not ordinarily exceed 120 to 130 F.

The pump and fan controls are interlocked with the main pump control so that they must be running in order for the main pump to run.

Furthermore, large dial type thermometers are mounted on the trolleys easily visible from the cage and the floor. These are checked several times per turn and any high readings are investigated at once.

The external pump arrangement is felt to be superior to any circulating means involving the main pump due to the fact that the external pump can be circulating the oil for additional cooling at times when the main pump is shut down.

As a matter of interest, it might be pointed out that leaks and high operating temperatures are the common problems not only on the hydraulic machines in this plant, but in the other plants as well.

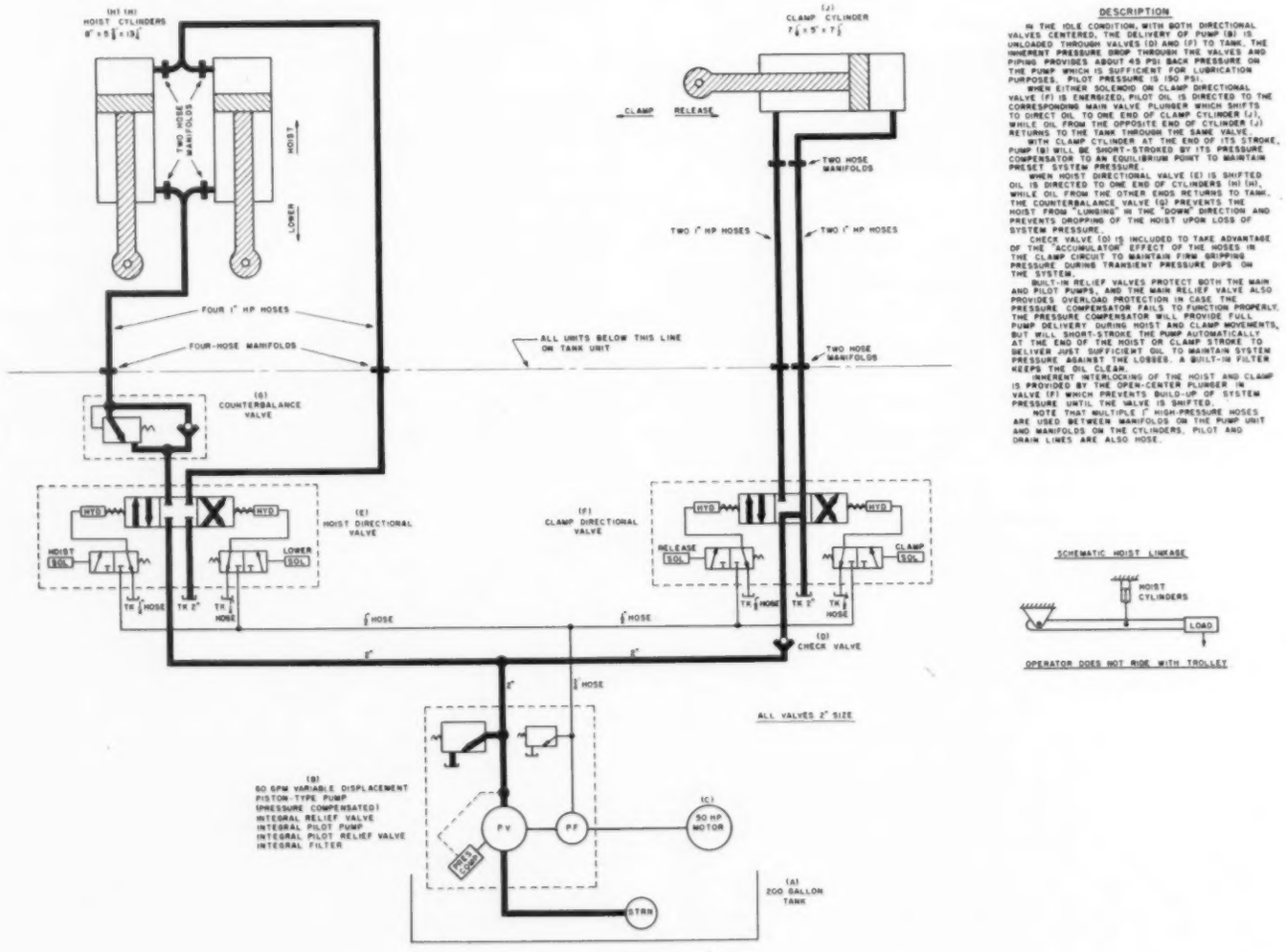
On the axle plant manipulators, where ambient temperatures are not high and most of the operation is at pressures under 600 psi, leaks are minimized by constant inspection and regular tightening of all connections. The axle plant furnace charger, with its low pressure, simple design, and lavish use of hose throughout, is practically trouble-free. The plate mill furnace charger is on a duty cycle that is not severe, and routine inspection and tightening are sufficient to keep it fairly leakproof.

The plant with the open hearth charger scheme shown on Figure 5 reports that the oil temperatures run too high in warm weather, when the machines must be shut down occasionally to cool off. These are low type machines with the power units set well back from the furnaces. Heat exchangers would undoubtedly improve this system. Incidentally, this system operates at about 1200 psi.

The plant with the scheme shown on Figure 6 reports that the one-pump system has not constituted a temperature problem, but that leaks are a source of trouble requiring considerable attention. The operating pressure ranges from 1200 to 1400 psi.

The one-pump system shown on Figure 7 has given the third plant very little trouble. Leaks in the welded steel tubing lines were a problem until it was found that they could operate at between 900 and 1000 psi instead of at the recommended 1700 psi. As this is a low type machine with the one-pump power unit placed

Figure 11 — The present design for the hoist and clamp motions of the high type open hearth charging machine uses a one-pump system.



well back from the furnaces, high temperatures are not a problem.

On our own open hearth chargers, the improvements to the original systems very greatly reduced maintenance, oil consumption, and delays.

However, there were still too many leaks and hydraulic control troubles on the power units themselves. It was therefore decided to experiment with various simplified one-pump systems with the ultimate aim of reducing the number of hydraulic components to an absolute minimum.

The first experiment is shown schematically on Figure 9. Note that the use of the variable-displacement pressure-compensated pump eliminated all of the complicated unloading devices present on Figure 1. The big accumulator, needle valve, and two check valves were eliminated. The pressure operated check valve which had been found unnecessary was not included. One pump and its relief valve were not necessary. With the addition of the by-pass filter, the reduction in hydraulic components from Figure 1 to Figure 9 (not including the tank which is not a leakage source) was from 20 to 12. This was a net reduction of 8 components, or 40 per cent.

This scheme performed very satisfactorily, but the pump proved to be extremely sensitive to very fine dirt which worked into the system and maintenance on the pump was excessive. Furthermore, it was felt that the great improvement in leakage with the reduction in hydraulic components indicated that much was to be gained by further effort in the same direction.

Accordingly, the scheme shown on Figure 10 was developed and put into service. Note that the pressure-compensated variable-displacement pump has a number of items built integral with the pump which were external to the pump in the previous schemes. This means, of course, that any leakage from these components goes directly back to the tank and oil loss is eliminated from these sources. Note particularly the integral filter and pilot pressure source. The balance of the system was identical with Figure 9. With this design, the reduction in hydraulic components from the original scheme on Figure 1 was from 20 to 9. This was a net reduction of 11 components, or 55 per cent.

This design was very satisfactory both from an operational and maintenance standpoint. However, the oil temperatures were rather disappointing, inasmuch as it had been expected to be able to operate without heat exchangers. Furthermore, considerable solenoid coil trouble was still experienced with the directional valves. In order to reduce the friction losses through the system and eliminate the oil leakage into the solenoid chambers, it was decided to rebuild the unit with larger valves of a different design.

The present improved design is shown on Figure 11. Note that all valves were increased in size from 1¼ to 2-in. Note also the diminution of the small accumulator. Experiments with the previous design indicated that the small accumulator was not necessary because of the "accumulator" action of the flexible hoses in the clamp circuit. With this design, the reduction in hydraulic components from the original scheme on Figure 1 was from 20 to 8. This was a net reduction of 12 components, or 60 per cent.

This power unit has been in operation for quite a few months and has proven to be quite satisfactory. Leakage on the power unit itself is practically nonexistant, and the improved hose connections to the cylinders give very little trouble. Some leakage around the cylinder ram packings does occur, but this is felt to be inevitable. Oil temperature is still not all that was expected, but it does appear that the heat exchangers will have to be used only on very warm days to hold the tank temperatures down below 150 to 160 F. The solenoid problem is practically eliminated, and with the solenoids now located in a very accessible location, the new failures do not contribute appreciably to delays.

In view of the highly satisfactory performance of this unit, all six of the charges are being equipped with duplicate units as rapidly as possible.

Summarizing this experience with hydraulic systems of these types, it can be stated that the very best maintenance and repair organizations and procedures are powerless to acceptably and economically maintain systems which are not properly designed for the specific heavy-duty conditions found on chargers and manipulators in a steel plant.

From the standpoint of design, the following features seem to be of utmost importance:

1. *Simplicity.*
   The fewer the components, the fewer the sources of leakage or trouble. Even if first cost is higher, insist on equipment requiring a minimum of exposed valving and gadgets.
2. *Design for minimum operating temperature.*
   Usually the ambient temperature cannot be controlled. Therefore, insist on hydraulic circuits which put the least amount of heat into the oil. Provide heat exchangers because undoubtedly they will be needed under extreme conditions on most machines, especially at the higher pressures. Try to locate the power units, lines, and cylinders away from the sources of direct or radiated heat from furnaces, stacks, and the like. In any event, install readily visible temperature indicators which will indicate operating oil temperatures at all times.
3. *Ruggedness.*
   Piping, valves, pumps and lines should be strongly supported by means entirely independent of the high pressure joints. Motors and pumps must be firmly secured to the tank unit, and the tank unit in turn must be strongly fastened to the machine frame. High pressure hose will in some cases prove more rugged than steel pipe or tubing.
4. *Accessibility.*
   A well designed power unit or cylinder may be very hard to service if not properly located in the machine. Pumps, motors, valves, and solenoids must be located at the most readily accessible points. Design the power unit with its location in the machine in mind.
5. *Ease of unit removal and replacement.*

In many cases replacement of the entire power unit is preferable to hunting trouble on, or individually servicing each component part. Frequently the use of high pressure hose rather than rigid piping will facilitate unit replacement. Conduits and other electrical components should be designed in a manner that will not restrict removal and replacement of the power unit.

Obviously, even a well designed system will require a certain amount of routine maintenance. It has been found that the following maintenance procedures are of considerable importance:

1. *Regular visual inspection.*
   Inspect each machine once per turn for oil level, unusual noises, leaks, and physical damage. Check oil temperatures on permanent dial indicators *several* times per turn.
2. *Periodic tightening and adjustment.*
   At regular intervals, usually weekly, tighten and adjust each system. This will prevent "O" ring failures due to loose joints and will provide some indication of the condition of the valves and pumps.
3. *Oil tests.*
   Oil tests are obviously useless on systems which are leaking so badly as to require large additions of new oil daily. However, on tight machines, oil tests for viscosity, acidity, and suspended material are of value if taken regularly at periods not exceeding about three months.
4. *Hydraulic test device.*
   Subject power units are rebuilt at the central machine shop. The entire completed unit is tested on a test device which duplicates the operation of a charging machine hoist. This device is nothing more than a permanently mounted hoist cylinder loaded with a sufficient weight to approximate the hoisting load on the charging machine. Permanent controls are also provided for the motor and solenoids. By timing hoisting speeds and checking pressures, any malfunction can be detected and corrected before the unit leaves the shop. Individual components may be tested by using a spare power unit as a test rack and checking operation of the unit incorporating the component to be tested.

In conclusion, it might be observed that even in the face of the admitted difficulties with the hydraulic machines, it must be conceded that they have a number of definite advantages. The inherent load-limiting feature is a great advantage, as any crane maintenance man in a steel plant can readily realize. The smooth movement of the hoist and clamp is very popular with the operators and develops a rhythmic operation that hastens material handling more than comparative operating speeds would seem to indicate. Furthermore, consistent improvement of the hydraulic systems will undoubtedly make them more desirable as time goes on.

Inasmuch as the hydraulic machines are obviously here to stay, it is hoped that the experiences as set forth in this paper will be of value to those who may be now or at some future time faced with similar problems.

DISCUSSION

PRESENTED BY

H. W. BALL, Technical Advisor to the President, The Morgan Engineering Co., Alliance, Ohio

SAMUEL J. SMOLY, Product Improvement Dept., Vicker Inc., Detroit, Mich.

GORDON M. KYLE, Assistant Superintendent, Mechanical Dept., Inland Steel Co., East Chicago, Ind.

H. W. Ball: Of the hydraulic machines covered by Mr. Bogar in his paper, I should like to speak particularly of the hydraulic charging machines as this is the machine with which I am most familiar.

When this machine was developed it was my intention to improve on charging machines which had had very little change in their design for many years. The following points were those which I felt required changing.

In years past it has been the operating policy of many steel mills for all persons on the open hearth floor to look out for charging machines as it was impossible for the operator to have good vision in the immediate area next to his machine. To accomplish better vision, hydraulic cylinders were used on the hoist, thus eliminating the gearing, large horse power motor and brake, which invariably obstructed the operator's line of sight.

A better method of clamping the scrap box to the peel head was suggested. The method up to this time had been to insert a pin or key in the box in such a manner that it was locked to the head of the peel. This was accomplished by means of linkage and levers that tended to ride with the peel. This created a hazard in the cage where standing room is at a premium. Not only could it strike the operator, but it was most difficult to manipulate causing operator fatigue. Also, as the pin or key and the hole or slot in the scrap box would wear, the scrap box would become very loose on the head of the peel, contributing to the breakage of the peel and wear on the head. On the hydraulic machine it was possible to clamp the box to the head of the peel in the same manner that one places an article in a vise. It was not necessary for the operator to set the peel at any particular depth in the box, as the strength of the clamp was such that with only a moderate amount of grip the box would be very securely held.

Originally the machines were designed with the large 2-in. four-way control valves located in the operator's compartment. This placed the high pressure lines in such a position that if a line failed the fluid could be sprayed on the operator at the extremely high pressures. Later it was found practical to move these valves to the outside of the operator's compartment and manipulate them by means of pilot valves either hydraulically or electrically operated, according to whether the operator was located on the bridge or on the trolley. This proved to be a great improvement.

The use of flexible hose added to the problems as they have their limitations as to pressure in the larger diameters. Thus a manifold arrangement using smaller

diameter hose proved to be far more satisfactory.

Mr. Bogar spoke of the difficulty experienced in the use of solenoid operated valves. Much of this difficulty was due to the manufacturer having not developed his equipment rugged enough for steel mill use. Originally the hydraulic machines were developed on the basis of using 1800-psi pressure. This was revised on later type machines to operate at 1200 psi, thus reducing the severe shock experienced originally.

While I am certain that the ultimate in charging machines has not been accomplished, I do feel that in spite of the many difficulties encountered along the way, that some of the original purposes were realized.

Samuel J. Smoly: In going over some of the points outlined by Mr. Bogar I would like to discuss his point on using a simple circuit.

All hydraulic circuits are basically constituted of four principal parts. The hydraulic pump and prime mover are called the input or "A" end. The hydraulic motor, whether rotary or linear, is the output end and is referred to as the "B" end. The third principal part of a hydraulic circuit is called "valving" and the last but not least is the very important "piping." The valving can be broken down into three groups—pressure controls, directional controls and volume or speed controls.

A very simple circuit composed of a pump, a maximum pressure control relief valve, a four-way valve and a hydraulic cylinder can be called a somewhat basic circuit since many refinements can be introduced according to amount and type of control desired. Refinement of control relieves careless operators of many responsibilities, making the machine safe and foolproof. These refinements could be electrical, hydraulic or combinations of both. In the charger application, the basic circuit appears to be very desirable from a maintenance standpoint as pointed out by Mr. Bogar. However, we are totally dependent upon the reliability of the operators.

Another point Mr. Bogar covered was the heat problem. Since hydraulics is a branch of engineering science which deals with the practical application of the laws of hydrodynamics, and the chief physical properties of a fluid which affect its motion are its density, viscosity and compressibility, and since viscosity varies appreciably with temperature, many various means are employed in reducing the heat factor. Pumps discharging to the reservoir under full pressure waste horsepower and generate heat. Therefore, some means must be employed to either unload the pump at zero pressure or reduce the amount of oil discharged to the tank at high pressure to a bare minimum. In addition, some type of heat exchanger must be considered where ambient temperatures reach dangerously high figures.

Running clearances are kept to a very close minimum in hydraulic components to assure high efficiency of performance at high pressures. The tolerances are held in many cases to a 0.002 in., plus or minus 0.001 in. Therefore, the fluid used in the system must contain high lubricating qualities to prevent scoring, galling and premature excessive wear of parts. If the lubricity is lost through high temperatures or should the lubricant that is used be too thin, the conditions are those approaching solid friction; excessive power is consumed, wear is continuous and the heat produced expands the metals until they seize. Also, since running clearances are fixed, when the oil is thinner, internal leakage or slippage becomes a grave problem as slippage causes heat. A viscious circle or chain of reactions is instituted. Heat causes a decrease of viscosity; the decrease in viscosity causes increased slippage; the increased slippage causes heat; and this continues until a failure occurs.

Shock was also covered in Mr. Bogar's paper. Newton's laws of motion are applicable to hydraulic drives as well as mechanical drives. For obvious reasons, one does not attempt to stop an automobile by hitting a tree, yet many operators of hydraulically-operated machinery attempt to stop a heavily loaded cylinder from full speed to full stop in practically zero time. Great shock is experienced and the weak spots appear very quickly. It appears that in some instances deceleration control may be very desirable and vital.

The most troublesome problem discussed was oil leakage. Leakage of oil from hydraulic piping and fittings is greatly aggravated by high pressure and high temperature since they cause material stretch, curing of seals and leakage through the tapered pipe threads used. Shock or peak pressures cause destructive damage to flares and tubing as well as cause bolt stretch, which is the first step toward "O" ring failure. By controlling the temperatures, shock or peak pressures, and keeping operating pressures low by increasing areas of cylinders, leakage can be and is eliminated.

In conclusion and in addition to Mr. Bogar's recommendations that proper design and proper maintenance be of utmost importance in any hydraulic system; proper instruction of operators in handling of these highly precision machines seems an added precaution which has payed dividends to the ones that have exercised this caution.

Gordon M. Kyle: I feel that we owe Mr. Bogar a vote of thanks for describing the difficulties and subsequent remedies for the rather involved hydraulic system on his charging machines. I am quite sure that most maintenance people will agree with the five essential features stated in the latter part of the paper, particularly with regard to simplicity, ruggedness and accessibility. It seems pertinent to state that the factor of ruggedness is often overlooked and should be included on any hydraulic system to the extent that all piping should be firmly clamped to prevent leakage.

At Inland Steel we do not have forging manipulators, but we do have 13 charging machines in our open hearths. In every case the operator rides the trolley. All of our machines are equipped with conventional electrical-mechanical hoists, all of which perform in a satisfactory manner. For our gripping motion we use the lock-rod method and have applied both pneumatic and hydraulic power to the lock-rods. Both of these systems have performed very well. In order to reduce the multiplicity of hydraulic components, we located the control valve in the cab by the operator, and eliminated the need of any solenoids, additional piping and hoses, or extra valves.

By B. M. OSOJNAK, Assistant to Vice President of Engineering, Heyl and Patterson, Inc., Pittsburgh, Pa.

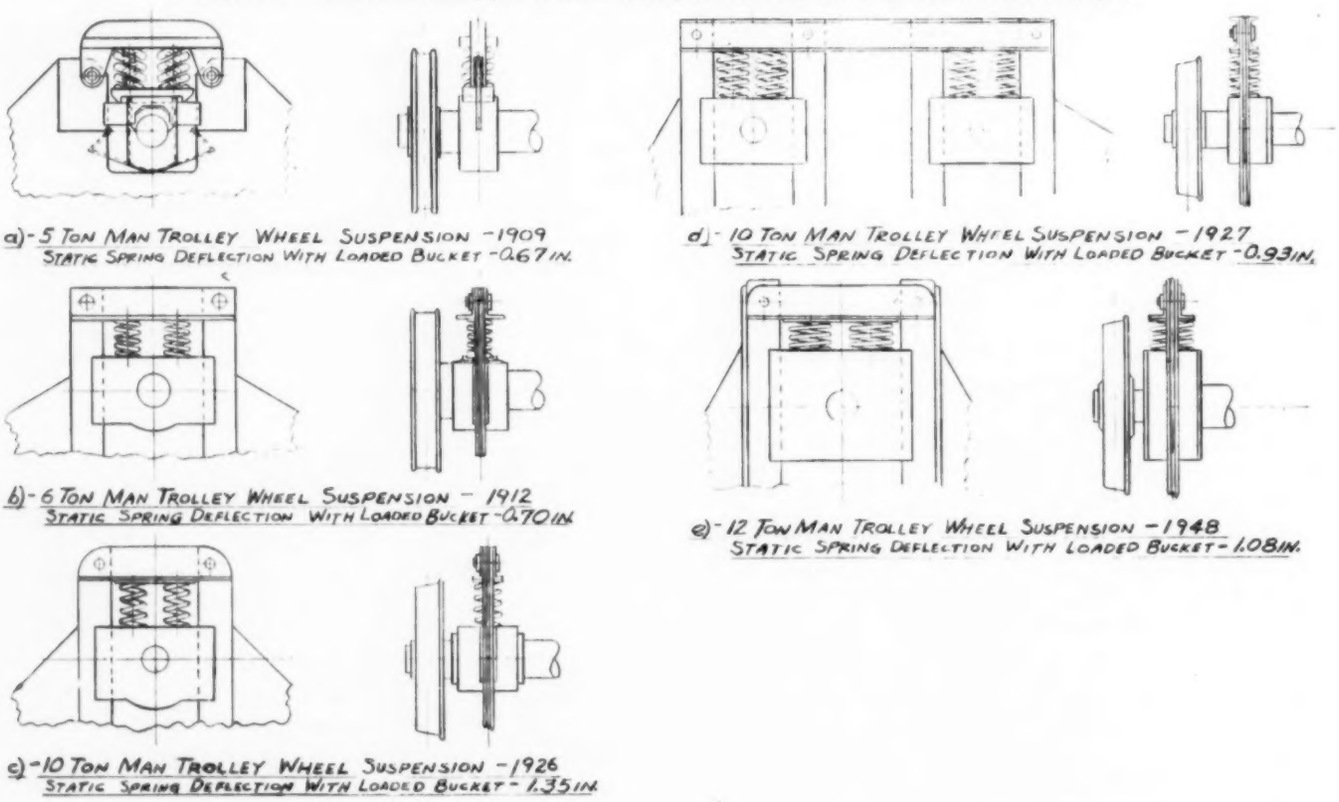
An Analysis of WHEEL SUSPENSIONS on Ore Bridge Man Trolleys

. . . . maintenance on ore bridge trolleys can be reduced by incorporating special rubber cushions in the design . . . . number of parts are reduced and fewer items require lubrication . . . . a value of 400,000 lb per in. at each wheel for the suspension spring rate seems to give the best balance . . . .

▲ THE simplification of machinery design together with the attainment of better performance is the constant desire of the designer and the operator. In an endeavor to simplify design and reduce maintenance on ore bridges, the wheel suspension of the man trolley was selected as a promising point for study.

Up to the present time the usual man trolley suspension has consisted of an axle bearing housing, a yoke fixed to the trolley and heavy coil springs between the two. As seen on Figure 1 the entire spring suspension design has followed the practice of the railroad industry since this system has represented a proven way of handling high wheel loads on trackage similar to that existing on many ore bridges. Although the spring deflections are only about three-quarters of an inch, several problems arise in the man trolley travel drive as a result of this feature. One problem is the need of providing guide shoes between the axle housing and yoke to provide a renewable wearing surface that can also be shimmed as wear occurs and thereby minimize mis-

Figure 1 — Chart shows types of man trolley wheel suspensions used in older designs.


a) - 5 Ton Man Trolley Wheel Suspension - 1909
Static Spring Deflection With Loaded Bucket - 0.67 in.
b) - 6 Ton Man Trolley Wheel Suspension - 1912
Static Spring Deflection With Loaded Bucket - 0.70 in.
c) - 10 Ton Man Trolley Wheel Suspension - 1926
Static Spring Deflection With Loaded Bucket - 1.35 in.
d) - 10 Ton Man Trolley Wheel Suspension - 1927
Static Spring Deflection With Loaded Bucket - 0.93 in.
e) - 12 Ton Man Trolley Wheel Suspension - 1948
Static Spring Deflection With Loaded Bucket - 1.08 in.

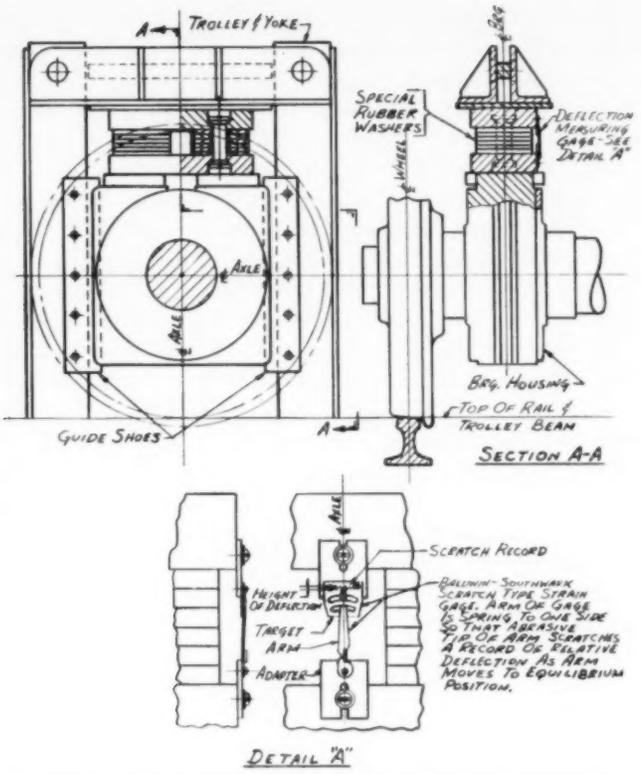


Figure 2 — Trolley suspension with special rubber medium was found beneficial and reduced collector shoe arcing because of smaller vertical motion of trolley. Lower sketch shows scratch gage used to measure deflection.

alinement of the wheels. The other problem that presents itself is the connection between the motor and the gear housings. As a result of the relatively large vertical motion of the axle, it is necessary to provide a flexible coupling of more than usual flexibility between the motor and the gear reducer or else mount the travel motor on a cradle suspended from the axle. Neither of these alternatives in this case is particularly attractive, since a more flexible coupling requires additional space while a cradle adds weight, cost, and maintenance to the trolley.

With the advent of the continuous welded rail and its possibilities for a smooth ride, it became readily apparent that a stiffer yet satisfactory suspension could be designed that would eliminate the guide shoes and cradle and lower the maintenance on the unit as well. Such a design would be a distinct improvement upon the usual spring suspension. To evaluate the merits of a stiffer suspension, it was felt that an existing trolley suspension should be reworked first and thoroughly checked in the field under operating conditions before a new design was made based on these features. Accordingly, a recently built ore bridge trolley at a central Pennsylvania steel mill was provided with a low deflection suspension and tested under various conditions. This bridge has no apron and employs continuous welded trolley rails.

A special rubber was chosen for the suspension medium because of its excellent durability, damping capacity, lack of bulging that common rubber exhibits and because of satisfactory results obtained with it over the past years for heavy shock applications on railway equipment and heavy presses. The design shown on Figure 2 was installed and proved itself superior to the former suspension in all respects. An unexpected benefit of the low deflection suspension was the elimination of collector shoe arcing under digging conditions as a result of the much smaller vertical motion of the trolley.

To establish a wheel suspension flexibility that will produce satisfactory operation, the following factors must be evaluated and acceptable limits set on each. Field test data as well as a theoretical analysis were used to arrive at a suspension flexibility that satisfied the following factors:

1. Impact loads on wheels, axles, bearings and structure when running over the track.
2. Bridge loads arising from sudden lifting of the loaded bucket.

TABLE I

Variation of Track Impact Loads with Suspension Stiffness

	Suspension stiffness		K = 40,000 Lb/In. Standard springs of trolley		K = 400,000 Lb/In. Approximate stiffness of special rubber		K = 800,000 Lb/In.	
			Trolley velocity, fpm					
	Item	Units	530	1000	530	1000	530	1000
1	ω_n Natural frequency	Rad/sec	21.7	21.7	68.5	68.5	97.0	97.0
2	F Natural frequency	Cycles/min	207	207	655	655	925	925
3	ω Forced frequency	Rad/sec	122	230	122	230	122	230
4	ω_n/ω		0.178	0.0945	0.561	0.298	0.808	0.422
5	$(\omega_n/\omega)^2$		0.0318	0.0089	0.315	0.0887	0.652	0.177
6	$1-(\omega_n/\omega)^2$		0.9682	0.9911	0.685	0.9113	0.348	0.823
7	t Equation (12)	Sec	0.0126	0.0068	0.01094	0.00648	0.00958	0.0062
8	sin $\omega_n t$		0.2692	0.14752	0.67944	0.42894	0.8007	0.56305
9	sin ωt		0.99953	0.99996	0.9730	0.99676	0.92050	0.98923
10	P_i Equation (11)	Lb	2,460	2,490	21,600	23,800	39,300	45,500
11	P_{il} Equation (13)	Lb	2,500	2,500	25,000	25,000	50,000	50,000

Assumption for above calculations:

D—Wheel diameter . . . . . 30.0 in.
X_o—Height of bump . . . . . 0.0625 in.
W—Wheel load . . . . . 32,800 lb (nominal)

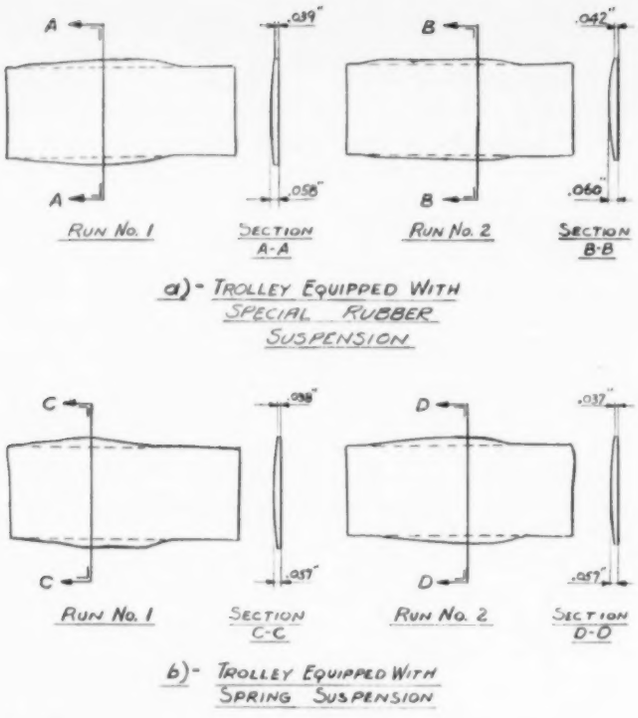


Figure 3 — Sketches show effect of running trolley off $\frac{1}{16}$-in. thick mild steel blocks.

3. High frequency vibrations, or noises, transmitted to the trolley operator.

1. A theoretical derivation of the result of running over an obstruction on the rail is given in Appendix B. The results of this analysis are given in Table I for a range of suspension stiffness from that of springs to twice the stiffness of the special rubber test unit. As a rough correlation of the theoretical work, steel blocks about one inch wide and $\frac{1}{16}$ in. thick were placed on the rail to simulate a rail joint. The results of the flattening tests at a given trolley speed are shown on Figure 3 for a trolley with the spring suspension as well as the special rubber suspension.

It is recognized that this test is rather insensitive, but the differences in the "squashing" of the bars were not appreciable and therefore indicated that the impact forces were of a similar order. The theoretical results of Table I show that impact forces increase approximately in direct proportion to the stiffness. Other modifying factors that make the impact forces even less responsive to the suspension stiffness are the bridge structure and trolley stringer flexibility. These items were not considered in developing the data of Table I.

In addition to the flattening tests, deflections of springs as well as of the special rubber inserts in running over $\frac{1}{16}$-in. thick bars were recorded by scratch gages in an installation as shown on Figure 2. The recorded impact load of 1480 lb (Table III) for the spring equipped trolley is considerably below the theoretical value of 2460 lb (Table I). In a similar way with the special rubber suspension the recorded values are less than the theoretical. Even though the experimental measurements are meager and subject to perhaps as much as 20 per cent error, it is clear that additional flexibility in the structure is helping to minimize the impact loads.

Estimation of spring rates of the special rubber is complicated by the non-linear load curve as well as the large amount of damping or hysteresis that this material exhibits. The theoretical results were based on the special rubber having a stiffness of 400,000 lb per in. whereas the observed static deflection of $\frac{1}{4}$ in. would lead to a spring rate of 160,000 lb per in. and the recorded strain readings indicated spring rates of 550,000 lb per in. at the front wheels and 1,200,000 lb per in. at the rear wheels. Since the last two spring rates should not differ from each other appreciably, the dif-

TABLE II

Effect of Wheel Suspension Flexibility on Maximum Impact Hoist Loads

	Wheel suspension stiffness per wheel, lb/in.					
	Usual spring suspension			Special rubber suspension		
	K = 40,000	K = 80,000	K = 250,000	K = 500,000	K = 1,000,000	K = Infinite
K_w Lb/In., Equation (18)	14,800	15,500	16,000	16,150	16,250	16,300
$\sqrt{K}$	122	125	126	127	127.5	128
Maximum relative impact load P_{2max} under hoisting conditions, Equation (20)	1.00	1.02	1.04	1.04	1.05	1.05

For illustration trolley
Let a—123 in.
b—195 in.
L—318 in.
u—720 in.
d—1.125 diam, in.
I—5000 in^4;
E′—12 x 10^6 psi
E —30 x 10^6 psi

TABLE III

Results of Field Tests on 12-Ton Man Trolley

No.	Condition	Spring suspension		Special rubber suspension	
		Left front	Left rear	Left front	Left rear
1	Wheel load due to calibration with empty bucket	7,200	4,600	7,200	4,600
2	Average deflection for Item 1, in.	0.172	0.115	0.013	0.0038
3	Apparent spring rate per wheel, lb per in.	42,000	40,000	550,000	1,200,000
4	Maximum wheel reaction due to hoisting empty bucket from rest to maximum speed, lb	10,400	7,600	—	—
5	Maximum wheel reaction due to hoisting loaded bucket from rest to maximum speed	15,700	—	15,000	—
6	Wheel reaction due to stationary loaded bucket carrying cinders, lb	—	—	10,500	—
7	Wheel reaction due to running over 1/16-in. thick block, lb	1,480	—	—	10,300
8	Nominal total wheel load with empty bucket, lb	32,800	40,400	32,800	40,400

Bucket weight empty = 24,000 lb

ference was probably due to the local deflection of the members to which the gage was attached. The difference in spring rates does not affect the accuracy of the data since a calibration was carried out with each gage.

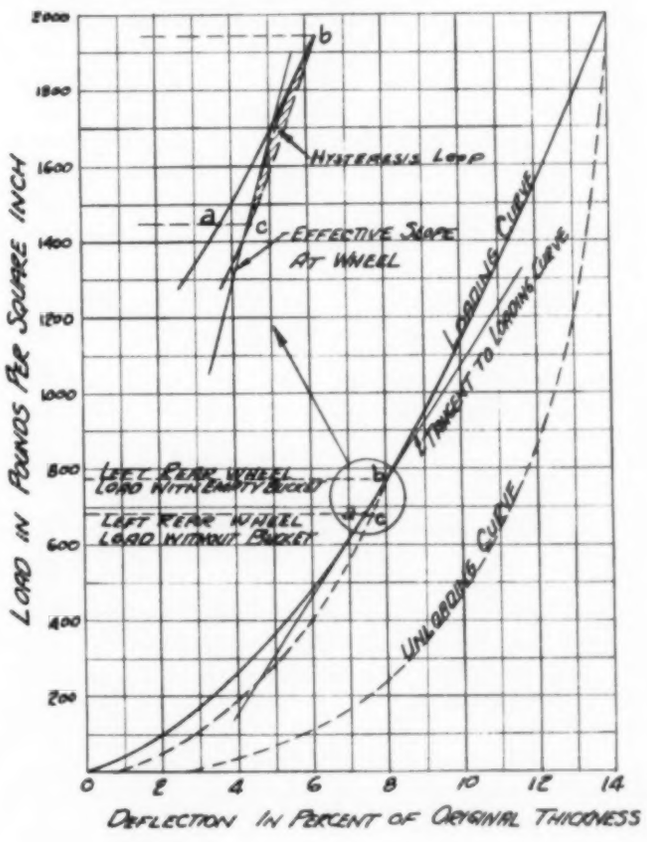
2. The most severe hoist shock loads occur when a loaded bucket is "jerked" from an ore pile. Assuming a given amount of kinetic energy E_k is stored in the rotating parts of the hoist engines, Appendix C establishes the influence of the wheel suspension stiffness on the hoisting impact loads as a result of the suspension, trolley frame and rope deflections. The absolute impact load would be difficult to establish since the stored energy in the rotating parts varies according to the method of operation but relative impact loads can be determined. As could probably be summarized, hoisting shock loads shown in Table II are influenced very slightly by the stiffness of the suspension. In fact a trolley affixed solidly to the axle would show only 5 per cent more impact load than the original spring suspension and even this figure is on the high side since bridge flexibility was not considered. From the above discussion it can be concluded that the suspension flexibility plays a very small part in determining hoisting impact loads.

3. From past experience we know that a large carriage running directly on rails without any flexibility in the supports will be noisy due to the resonant vibrations of the many flat panels as a result of the low amplitude high frequency vibrations arising from the track and wheel irregularities. Records show that even a single thickness of rubber ½ in. thick between spring and seats on railway passenger cars greatly reduced the noise level in the passengers compartment. For this reason at least, it seems that some flexibility need be provided between wheel and trolley structure. From the test of the 12-ton ore bridge trolley, the noise level in the cab appeared to be about the same for the trolley equipped with either springs or rubber. This observation would indicate the suspension may be stiffened even further than that of the rubber suspension of Figure 2 without introducing an undesirable noise level.

SUMMARY

The suspension deflection can be made sufficiently small so as to dispense with the travel motor cradle and the axle guide shoes. Such a change will very definitely

Figure 4 — Load-deflection curves for special type rubber mounting material are given here.



reduce maintenance by the elimination of many physical parts and lubrication points. Reduction of vertical motion also has considerable merit in reducing the power pickup shoe maintenance by minimizing their arcing.

Hoisting shock loads are influenced to a very small extent by variation of the suspension stiffness in the range commonly used. Selection of suspension stiffness need not be affected by this factor. Although the reduced deflection slightly increases the wheel impact loads, the increase is not significant.

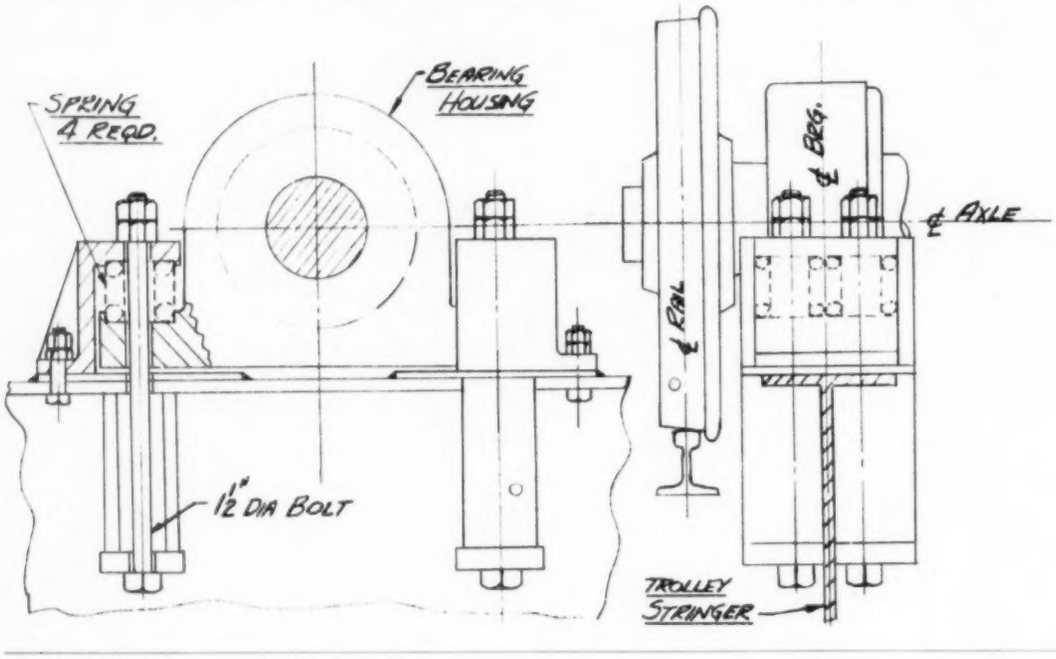


Figure 5—Sketch shows proposed wheel suspension design which used low deflection springs.

A design value of about 400,000 lb per in. at each wheel for the suspension spring rate appears to be a reasonable balance of the three factors analyzed. It should be noted that this spring rate must be evaluated at the nominal working stress of the material. Rubber, for instance, has a variable spring rate which depends upon the stress imposed on it and also upon the motion at the stressed point as a result of the internal damping of the material. A suggested design of a low deflection wheel suspension is shown on Figure 5.

APPENDIX A

Derivation of Equations:

Symbols used in the Analysis

X_o—Height of theoretical rail obstruction—in.

m—Idealized mass of portion of trolley carried over one wheel $\frac{\text{lb - sec}^2}{\text{in.}}$

R—Radius of trolley wheel — in.

l—Horizontal distance from wheel center to point on rim contacted by obstruction — in.

K—Flexibility of wheel suspension — lb per in.

t—Time — sec

F—Natural frequency of trolley vibration on its wheel suspension — cycles per min

ω—Circular frequency of forced vibration — rad per sec

ω_n—Circular frequency of natural trolley vibration — rad per sec

v—Trolley velocity — fpm

X—Vertical motion of mass m measured from its equilibrium position — in.

X_1—Motion of center of wheel in passing over a bump X_o high — in.

P_i—Effective impact force on axle above nominal wheel load — lb

P_{il}—Limiting value of P_i when natural trolley frequency ω_n is much less than forced frequency ω— lb

a—Distance from wheels (those on opposite end from cab) to center of bucket — in.

b—Distance from center of bucket to center of wheels over cab (rear wheels) — in.

L—Wheel base = a + b — in.

R_1—Front wheel reaction — lb

R_2—Rear wheel reaction — lb

W—Weight of bucket plus load - lb

u—Length of rope bucket on which bucket is hanging — in.

I—Inertia of one main trolley stringer — $in.^4$

E—Modulus of elasticity of steel 30,000,000 psi

E′—Modulus of elasticity of steel rope, assumed 12,000,000 psi

δ_1—Deflection of front wheel suspension — in.

δ_2—Deflection of rear wheel suspension — in.

Δ_1—Deflection of bucket due to bending of trolley stringers — in.

Δ_2—Deflection of bucket due to sag of wheel suspension — in.

Δ_3—Deflection of bucket due to stretch in two close ropes — in.

K_w—Effective flexibility at bucket — lb per in.

E_k—Kinetic energy stored in rotating parts of close engine — in. - lb

P_{max}—Maximum rope pull as a result of slack in close line allowing bucket to receive an impact — lb

δ_{st}—Static deflection of loaded trolley on its wheel suspension — in.

APPENDIX B

1. Dynamic axle loads due to trolley running over a theoretical obstruction.

Let wheel of radius (R) roll on rigid surface at v fpm over a rigid obstruction X_o high. See Figure 6. The weight of the trolley on the wheel can be idealized as a mass (m) supported by a spring of rate K lb per in. If obstruction height is small compared to wheel radius,

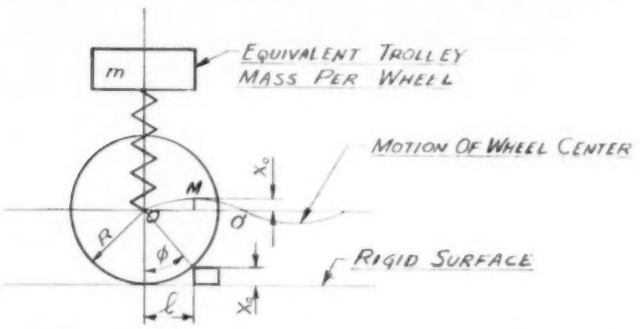


Figure 6 — Terminology used in equations is illustrated in this sketch.

the wheel motion would be represented by one half of a sine wave O-M-O'. Since wheel is always in contact with obstruction deflection of center O will be equal to X_o.

The frequency of the forced vibration can be found as follows:

$$\text{Time (t) to travel distance } l = \frac{l60}{12v} = \frac{5l}{v} \text{ sec} \quad \ldots\ldots (1)$$

Since O to M is one quarter of cycle time for complete cycle (T) is:

$$T = 4t = \frac{(4)5l}{v} = \frac{20l}{v} \quad \ldots\ldots (2)$$

for a harmonic forced vibration the circular frequency ω is:

$$\omega = \frac{2\pi}{T} = \frac{2\pi v}{20l} = \frac{\pi v}{10l} \text{ rad per sec} \quad \ldots\ldots (3)$$

For small angles of (ϕ) the following holds true:

$$\frac{X_o}{l} = \frac{l}{D} \text{ or } l = \sqrt{D \cdot X_o} \quad \ldots\ldots (4)$$

$$\text{Then} \quad \omega = \frac{\pi v}{10\sqrt{D \cdot X_o}} \quad \ldots\ldots (5)$$

The forced motion of wheel can be therefore represented by $X_1 = X_o \sin\omega t$. If X = deviation of mass (m) from equilibrium position, the differential equation of motion is:

$$m\frac{d^2X}{dt^2} = K\,(X_o \sin\omega t - X) \quad \ldots\ldots (6)$$

$$m\frac{d^2X}{dt^2} + KX = KX_o \sin\omega t \quad \ldots\ldots (7)$$

Solution of this equation is of the form:

$$X = C_1 \cos\omega_n t + C_2 \sin\omega_n t + P \quad \ldots\ldots (8)$$

where P is the particular function. With equation (7) and knowing that $X = 0$ at $t = 0$ and $\frac{dX}{dt} = 0$ at $t = 0$

Equation (8) reduces to:

$$X = \frac{X_o\left[\sin\omega t - \frac{\omega}{\omega_n}\sin\omega_n t\right]}{1 - \left(\frac{\omega}{\omega_n}\right)^2} \quad \ldots\ldots (9)$$

where ω = forced frequency rad per sec

$\omega_n = \sqrt{\frac{K}{m}}$ rad per sec or natural circular frequency

The effective impact force (P_i) on the trolley axle is:

$$P_i = K\left[X_o \sin\omega t - \frac{X_o\left[\sin\omega t - \frac{\omega}{\omega_n}\sin\omega_n t\right]}{1 - \left(\frac{\omega}{\omega_n}\right)^2}\right] \quad \ldots\ldots (10)$$

Simplifying equation (10) yields:

$$P_i = K\,X_o \frac{\left[\sin\omega t - \left(\frac{\omega}{\omega_n}\right)\sin\omega_n t\right]}{1 - \left(\frac{\omega}{\omega_n}\right)^2} \quad \ldots\ldots (11)$$

This function is a maximum at $\frac{d\,P_i}{d\,t} = 0$

or $$\frac{d\,P_i}{d\,t} = 0 = \frac{K\,X_o}{1 - \left(\frac{\omega}{\omega_n}\right)^2}\left[\omega\cos\omega t - \frac{\omega_n^2}{\omega}\cos\omega_n t\right]$$

hence:

$$\cos\omega t = \left(\frac{\omega_n}{\omega}\right)^2 \cos\omega_n t \quad \ldots\ldots (12)$$

If ω is much greater than ω_n the limiting value of P_i from equation (11) is:

$$P_{il} = K\,X_o \quad \ldots\ldots (13)$$

APPENDIX C

Effective combined flexibility at the bucket of trolley structure, supporting ropes, and wheel suspension.

Figure 7 is an idealized sketch of a trolley supported by flexible suspension and in turn holding a bucket. Assuming the maximum loads in starting to hoist the bucket are usually imposed on the two close ropes, the total flexibility will be as follows:

For a load W the deflection of trolley beams at point of load will be

$$\Delta_1 = \frac{W\,a^2\,b^2}{6\,E\,I\,L} \text{ in.} \quad \ldots\ldots (14)$$

Deflection of flexible wheel suspensions will produce a deflection of Δ_2 at point of load.

$$R_1 = \frac{W\,b}{L} \qquad R_2 = \frac{W\,a}{L}$$

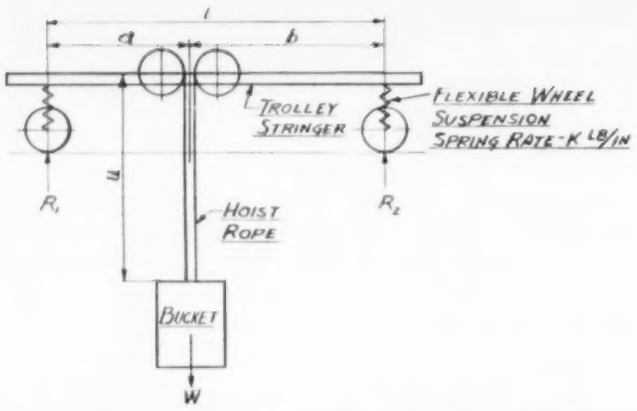


Figure 7 — Flexibility at bucket is a combination of that provided by the ropes, wheel suspension and beam deflection.

Deflection at

$$R_1=\delta_1=\frac{W\,b}{2\,KL}$$

at

$$R_2=\delta_2=\frac{W\,a}{2\,KL}$$

$$\Delta_2=\frac{W}{2KL^2}\left[aL+b^2-ab\right] \quad \ldots\ldots\ldots\ldots (15)$$

$$\text{Since } \Delta_2=\delta_2+\frac{b}{L}(\delta_1-\delta_2)$$

Deflection of two close ropes (Δ_3) will be based on steel area of rope, $= a_o$

where $a_o=0.4d^2$ (Assuming average factor for wire rope)

d = rope diameter — inch

Since total stretch of rope $=\Delta_3$

$$\Delta_3=\frac{Wu}{2\,E'\,a_o}=\frac{Wu}{0.8\,E'\,d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Summation of the deflection (1), (2) and (3) yields:

$$\Delta_t=\Delta_1+\Delta_2+\Delta_3=\frac{W\,a^2\,b^2}{6\,E\,I\,L}+\frac{W}{2\,KL^2}$$

$$\left[aL+b^2-ab\right]+\frac{Wu}{0.8\,E'\,d^2} \quad \ldots\ldots\ldots\ldots (17)$$

$$\text{Since effective flexibility at bucket} = K_w=\frac{W}{\Delta_t}$$

$$K_w=\frac{E}{\left[\dfrac{a^2\,b^2}{6\,I\,L}+\dfrac{E}{2\,KL^2}\left(aL+b^2-ab\right)+\dfrac{u}{0.8d^2\left(\dfrac{E'}{E}\right)}\right]\ldots}$$

lb per in. $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (18)$

If slack develops in the close lines before the bucket is hoisted and motor reaches a certain speed (N), at the instant the lines become taut, an amount of energy must be absorbed by the elastic system including trolley structure ropes and suspension. This additional energy will produce a maximum force in the system as follows on the assumption that the kinetic energy (E_k) is not sufficient to lift the loaded bucket due to the impulsive nature of the action and assuming that total deflections are proportional to load:

$$E_k=\tfrac{1}{2}\,P_{max}\,\Delta_{tmax} \qquad \text{but } \Delta_{tmax}=\frac{P_{max}}{K_w}$$

$$E_k=\tfrac{1}{2}\,\frac{P^2_{max}}{K_w}$$

The maximum force becomes approximately:

$$P_{max}=\sqrt{2\,E_k\,K_w} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

Determining P_{max} exactly is difficult but of main interest in the relative values of P_{max} as the wheel suspension stiffness changes.

From this equation it is seen that the maximum force produced will vary directly

as $\sqrt{K_w}$

or $\dfrac{P_{2max}}{P_{1max}}=\sqrt{\dfrac{K_{w2}}{K_{w1}}}$

if $P_{1max}=1.00$

$$P_{2max}=1.00\sqrt{\frac{K_{w2}}{K_{w1}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

APPENDIX D

Natural frequency of trolley as a measure of wheel suspension stiffness.

Impact conditions on the trolley are a function of both wheel suspension stiffness (k) and weight supported by the suspension. These two items can be condensed into one parameter by measuring the static deflection of a suspension which has a linear load deflection curve or by determining the natural frequency of the trolley on its springs. This provides an easy method of comparing the true quality of various suspensions:

The natural frequency of a trolley on its suspension is given by

$$\omega_n=\sqrt{\frac{K}{m}} \text{ rad per sec}$$

The vibratory frequency in cycles per minute is given by:

$$F=9.55\,\omega_n \quad \text{or } F=188\sqrt{\frac{K}{W}} \text{ cycles per minute (cpm)} \ldots\ldots (21)$$

This equation will give a fairly accurate result of a variable stiffness suspension rate by determining the average value of K in the range of loading. For linear load-deflection curves of wheel suspensions such as springs, this equation can be simplified by recording the static deflection of the trolley for a given load.

If $\delta_{st}=\dfrac{W}{K}$ then equation (1) reduces to

$$F=\frac{188}{\sqrt{\delta_{st}}} \text{ cycles per minute (cpm)} \ldots\ldots\ldots\ldots (22)$$

HOT SCARFING with a Mechanical Bloom Turner

By A. B. GLOSSBRENNER
Assistant General Foreman
Bloom Conditioning Dept.
Steel and Tube Div.
The Timken Roller Bearing Co.
Canton, Ohio

. . . . in a new hot scarfing system, production per man hour was practically doubled . . . . the increase was primarily due to better material handling facilities and use of a larger torch . . . . surface of hot scarf blooms has also improved . . . .

▲ The Timken Roller Bearing Co. recently installed a new hot scarfing system which has resulted in a better than 100 per cent increase in production but requires only 50 per cent of the previous manpower. The purpose of this paper is to touch on the preparation that went into this achievement and to present a complete description of the present system and how it works.

The Timken Roller Bearing Co.'s Steel and Tube Division produces alloy steel and tubing for both the bearing division and for outside customers. The clean up or conditioning of these various alloys is sometimes difficult and quite critical. Many high alloy types cannot be hand or machine chipped because of hardness. These steels had to be skin ground—probably the most expensive method of removing steel surface defects but often quite necessary in order to obtain comparatively clean surfaces and thereby avoid trouble in future rolling and processing.

THE ADVENT OF SCARFING

With the advent of improved oxygen torches and the reduction in the cost of oxygen itself, it was found feasible to skin scarf much of the grinding steel as well as some alloy types that had never really chipped properly. However, alloys with above forty points of carbon generally could not be subjected to the terrific surface heat provided by the scarfing torch which caused transverse cracking and breakup. It was discovered that preheating these critical steels to 700 F before scarfing reduced the heat shock and prevented cracking. This discovery opened the way to improved conditioning of more steels at less cost than grinding.

About this time our conditioning requirement began to soar as melting capacity was increased. Something had to be done quickly in order to set up a hot scarfing operation.

THE PROBLEM OF A HOT SCARFING AREA

The bloom conditioning area consisted of one building, 100 ft wide by 440 ft long, containing three pickle tubs, four chipping machines, ten swing grinders, five cold scarfing stations and about 8000 tons of piled steel blooms. Two 15-ton overhead cranes served this entire area. The building itself was surrounded with the melt shop to the north, the bar mill to the west, the annealing department to the south, and the bearing factory to the east. A 30 x 40-ft area was somehow set aside for a heating furnace in the main building where blooms could be charged and preheated before scarfing. The heated blooms discharged into a shed like structure, 180 ft long by 20 ft wide, where a midget overhead crane (20-ft span) picked up the blooms by magnet and moved them to any one of five hot scarfing platforms. The scarfed steel was moved back into the main building by a hydraulic pusher transfer. Two large 30-hp exhaust fans disturbed the smoke enough to move the worst part of it out of the building. A craneman, five scarfers and five scarfer helpers worked in this area. The helpers were necessary to aid the crane in moving the hot steel in the crowded space, to scrape scarfing slag from the steel, and to aid in turning the blooms which ranged from 6 x 6 to 11 x 13 in. The hot scarf production rate actually exceeded the cold scarf rate set by the scarfers in the main building, but that did not alter our obvious conclusion that the hot scarf setup was unsatisfactory.

THE FIRST BLOOM TURNER

During this time a satisfactory solution to our hot scarfing problems was taking shape but was not as yet fully developed. The key to this solution turned out to be a mechanical bloom turner.

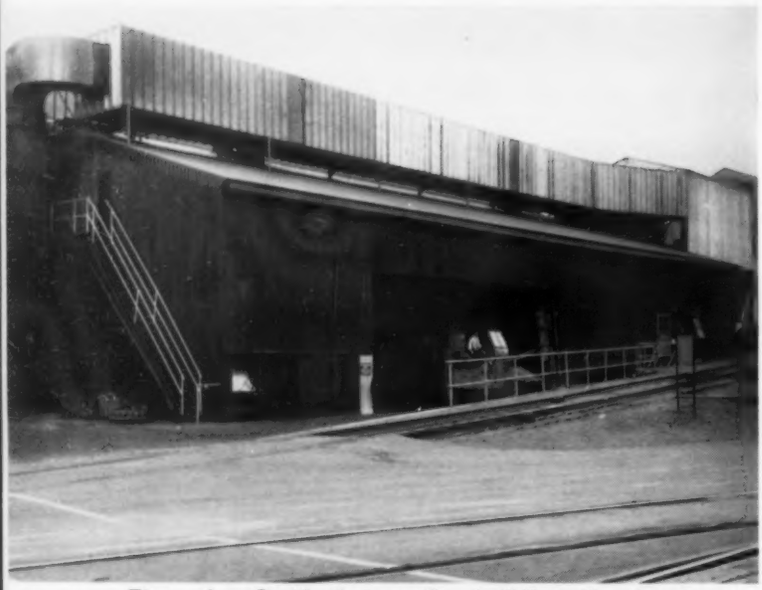


Figure 1 — On the hot scarfing building, the structure on the building's roof is the smoke tunnel which carries the heavy laden smoke into the collector room to the right of the picture.

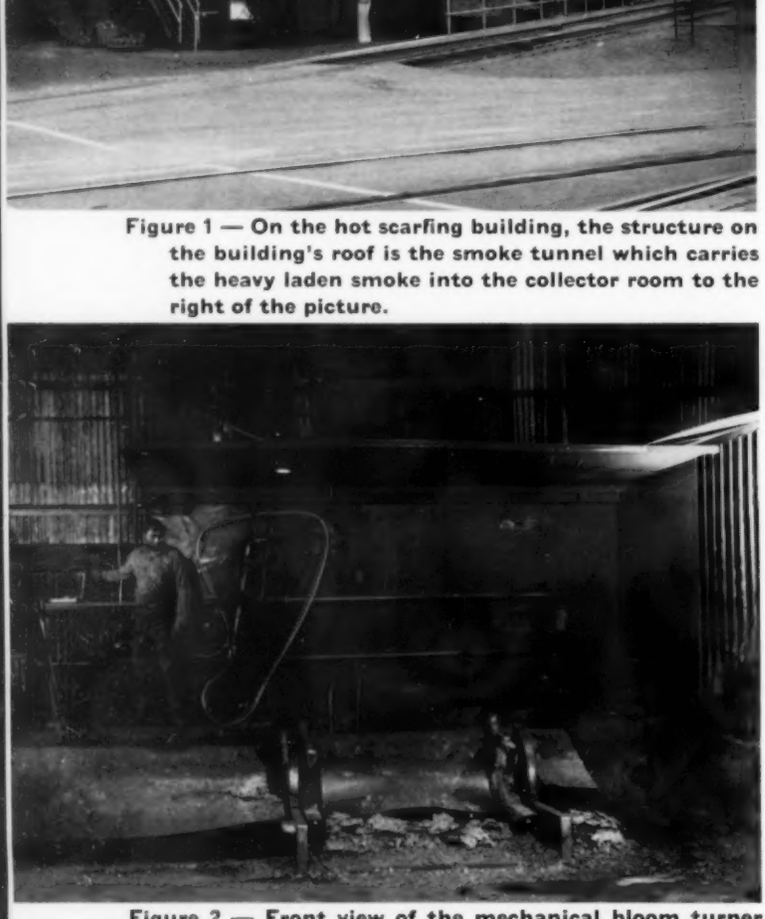
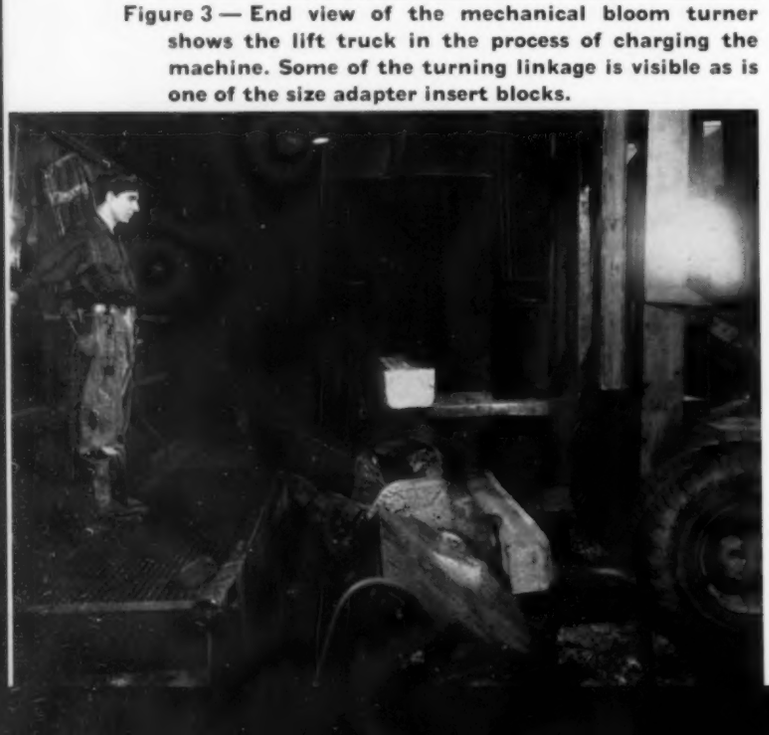


Figure 2 — Front view of the mechanical bloom turner shows the pickup arms, the slag plates and the smoke catcher to the right.

Figure 3 — End view of the mechanical bloom turner shows the lift truck in the process of charging the machine. Some of the turning linkage is visible as is one of the size adapter insert blocks.



For several years, our company experimented with some method of making it easier for a scarfer to handle the turning of heavy blooms. Finally the engineers worked out a simple machine which pushed and tumbled blooms a quarter turn at a time into a slot where the steel would be in a position for scarfing. This machine accomplished the turning satisfactorily but permitted only one bloom at a time to be charged or discharged by a crane and magnet. This limitation meant that 6 x 6-in. blooms could not be handled as quickly by machine as by hand. The larger size blooms were quite easily turned, but 6 x 6-in. ones had to be turned and scarfed two at a time in order to meet the desired scarfing rate.

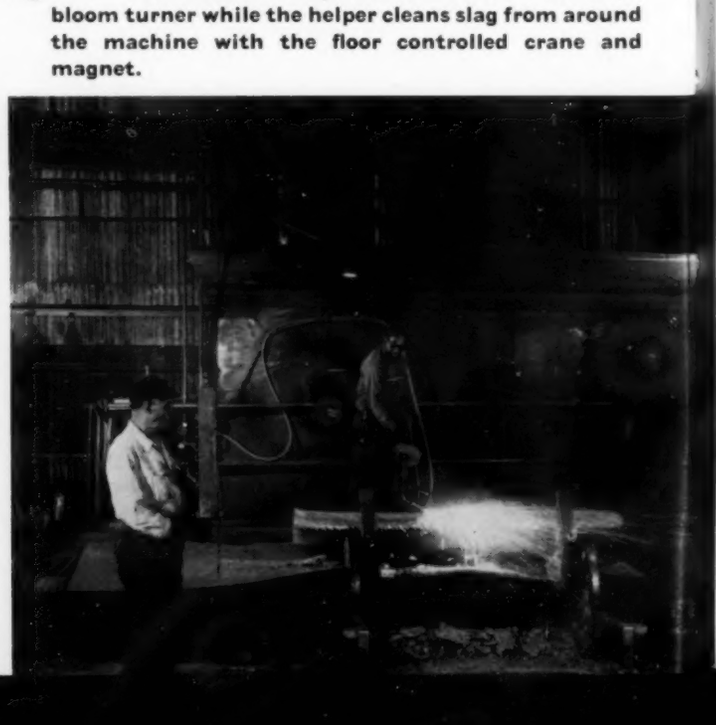
Early in 1953 conditioning requirements became so heavy that in order to squeeze whatever was possible out of the limited area it was decided to install the mechanical turner in a former truck garage shed next to the main conditioning building. The plan was to move steel to and from the burner by fork lift truck and in that way increase capacity. However, once in operation, certain possible changes in the machine's design became evident. Departmental supervision, a welder, and a burner went to work and by trial and error produced a machine that could be charged in half the time and could also turn two 6-in. squares simultaneously.

While experimenting it was decided to obtain additional information in order to see just what was now possible in the field of scarfing. The temporary operation was by then working around the clock. The size of the scarfing torch was changed from the small C-51 to the larger C-59. Time studies were made, and the tube potential began to be seen. A revised hot scarfing practice became apparent based not on theory but on actual operational experience.

APPLICATIONS OF THE RESULTS OF THE EXPERIMENT

A conservative estimate of production potential as indicated by the experimental work offered a production increase of about two tons per manhour over the existing hot scarf rate for a possible total of around five

Figure 4 — A hot scarfer in operation uses the mechanical bloom turner while the helper cleans slag from around the machine with the floor controlled crane and magnet.



tons per manhour. The additional oxygen pressure of the larger C-59 scarfing torch tended to blast the scarfing slag off the bloom surface and thereby eliminated the necessity of a helper standing by with a wire brush for use in removing the highly tenacious slag of alloy steels. It was also proposed to convert the previously mentioned midget crane in the old building to a floor controlled rig whose magnet could then be used for cleaning the scarfing slag, which is wholly magnetic, from around the turning machines and for loading drop bottom boxes. These boxes are used as containers both for the removal of the slag from the scarfing area and for direct loading into dump trucks outside the building. The use of the mechanical turner, the higher pressure torch, and the planned slag handling reduced the scarfer helper requirement to one man who would push steel from the preheat furnace and operate the crane to clean slag. Based on production requirements and reduced extra help the manpower needs for hot scarfing indicated a force reduction of 50 per cent.

The plan was accepted by management, and a short time later work was started on a slightly larger hot scarfing building. In order to make the change over with a minimum of delay the new building which was seven feet higher and ten feet wider was built over and around the old buildings. The old building was then removed and the midget crane stretched out to fit the new building. Four mechanical turners were built and installed; one at each end of the 180-ft building and one on either side of the preheat furnace discharge bucks. The side of the building opposite the furnace contains a large door opening which allows a heavy lift truck to move the finished steel in accumulated loads either back into the main building or into bolsters for straddle truck handling. In all, only five days of hot scarfing time were lost during the change over.

Once in operation it soon became painfully evident that the hot scarfing was producing more of that heavy laden, yellow smoke than the four 15-hp exhaust fans could handle. The higher carbon steels in particular are especially heavy smoke producers when preheated and when scarfed with the extra wide flame of the large torch.

The solution was the installation of large, louvered, smoke catchers at the end of each scarfing bed. Each catcher was hooked up to a 30-hp exhaust blower which sent the smoke into a stack and out of the building. Recently all four stacks were joined into a tunnel constructed on top of the scarfing buildings (Figure 1). This tunnel carries the smoke into a large enclosed area designed with two inner baffle walls and a hopper type bottom. The smoke enters one end of this room, drops the majority of the fine apprasive dust which it was carrying, and is blown out the opposite end still with a little color but not nearly so objectionable in the surrounding area.

OPERATION OF THE NEW INSTALLATION

After about ten days all parties began to become accustomed to the routine and new equipment of our new hot scarfing operation. A diesel powered, 20,000-lb capacity lift truck picks up the heated steel that the helper pushes out of the furnace onto a flat skid. The truck then moves the steel to the individual turning machines where the steel to be scarfed is placed on the mechanical turner's lowered pick up arms. The lift truck forks are then raised about 3 ft and the finished piece or pieces are removed from the top of the machine. A system was worked out whereby the lift truck could charge and discharge two machines before returning to the furnace skids for more steel. The scarfed pieces are accumulated on lay down skids until capacity loads are reached and then moved about 100 ft back into the main building. Should the main building crane become too busy to effectively handle all of this transferred steel, a portion of it may be loaded directly onto bolsters by the lift truck for straddle truck removal to other storage areas.

THE BLOOM TURNER IN OPERATION

Once the lift truck has placed new steel on the lowered arms of the bloom turner and removed the scarfed steel from the top side, the scarfer pushes a hydraulic control valve conveniently mounted on the back rail of his scarfing platform. This activates a 16-in., hydromotor coupled to the machine's main shaft but removed from the center of the scarfing slot by about 12 ft to avoid being overheated by the molten slag.

Small hydro-motors are not new, but the large 16-in. model has its first application in this turner. The hydromotor is simply a longitudinal vane attached to a shaft which runs through the core of a cylinder. Hydraulic pressure moves the vane, and this turns the shaft with sufficient torque to lift pick up fingers on which a bloom weighing better than two tons has been placed two ft from the shaft itself (Figure 2).

The blooms are moved in an arc from the base to the top of the machine where a simple, slotted linkage—like one end of a parallelogram—performs the necessary movement to accomplish the turning. The bloom rests diagonally in V-slots to allow slag to run off during scarfing and is turned toward the scarfer a quarter turn at a time. In its simplest form the turner is made up of two 3-in. plates, V-slotted and parallel about five ft apart. A heavy shaft runs through these plates with bearing supports on the outside and coupled to the hydromotor on one end. The turning linkage is attached to the shaft and located between the two side plates. (See Figure 3). A 20-ft platform runs parallel to the main shaft across the back of the side plates. This platform is floored with open grating to allow the molten sparks to drop through and thereby avoid burning holes in the bottom of the scarfer's shoes. This grating also permits a freer circulation of air around the man's feet and legs.

Experiments have shown that a torch 42 in. in length is the optimum for the average height man to comfortably handle while using the turner. A longer or shorter torch causes the scarfer to go into a contorted position which is very tiring. This torch is equipped with a composition hand shield about 10 in. square and placed about 20 in. from the hose end. Without this shield a

man would not be able to stand the torch's terrific heat at the point where his hands must grip the oxygen valve lever.

The rapid accumulation of slag under and around the moving linkage of the machine itself presented somewhat of a problem at first especially when the slag was pounded and packed under one of the lower moving members. This slag became so hard that it caused excessive strain such that the machine's full rotation was soon limited. Often it was difficult to break up this packed formation even with a pointed bar and sledge and much time was lost in cleanout work. The problem was solved when ¾-in. plates were installed to catch the slag as it ran off the blooms. These plates attached easily to the turning linkage and rotate over the main shaft with each turning cycle. This action loosens the slag and piles it up in front of the machine where the magnet can pick it up without causing the machine to be shut down (Figure 4).

The turner's main shaft support bearings are made of graph-mo steel and are supported individually to avoid any chance of misalinement caused by the impact of the 2-ton blooms falling into the positioning slots in the side plates. The side plates are welded to a heavy base plate which is held in place by four 1½-in. bolts extending up from a 2-ft concrete foundation. Severe bumping with the magnet and the lift truck have not altered the original alinement of the machine.

INEXPENSIVE POWER AND VERSATILITY

The versatility of the machine in the range of sizes that can be turned is accomplished by the use of different V-slot inserts. There is one set of inserts for the turning of the 6 x 6 in. blooms in pairs and another set for handling all other sizes from 8 x 8 up to 18-in. ingots. We have successfully worked all of the sizes indicated, but the most frequent sizes are 6 x 6, 9 x 9½ and 11 x 13 in.

The change for size takes only three to five minutes and is accomplished by the scarfer himself without additional help. There has been some wearing of these insert blocks, but individual heat treated sets have lasted better than two months before wearing out. The block is a simple outline and new ones are easily torch cut from stock plate so that replacement is no problem.

Space limitations again affected the new installation when it came to locating the hydraulic pumps and fluid reservoirs necessary to power the turner's hydrometer. It was decided to provide one pump and reservoir for two machines. This meant that only two pump setups were necessary—one at either end of the building. These are impeller type pumps driven by 15-hp electric motors. Because of the ever present danger of fire, especially where the hydraulic system is concerned, the reservoirs are filled with a non-inflammable hydraulic fluid. On several occasions this added expense has proven worthwhile. The flash point of any oil is considerably lowered when the oil is heated rapidly and ejected forth in a fine spray from some broken hydraulic connection. These breaks have occurred but without the danger of a fire.

THE INCENTIVE RATE AND RESULTS OBTAINED

It is interesting to note that a proposed rate of 5 tons per man hour was met and actually passed almost immediately. Some of the more experienced scarfers have reached exceptional tonnage on certain individual eight-hour turns. These high production turns tend to set goals toward which the average scarfer can strive. The mechanical turner and the big torch provide the opportunity, and a well planned incentive rate creates the desire.

The incentive rate installed in our hot scarfing operation is one that adjusts to the different sizes of blooms scarfed as well as to the different weights of these various sizes. The results have been most gratifying to all concerned and indicate a per cent of earned incentive that falls right into the accepted average for the steel industry.

At first there was some concern that the quality of conditioning would suffer so that quantity might be obtained. To the contrary, the surface of hot scarfed blooms actually was improved. The wider flame of the large torch means fewer passes to a side and therefore leaves fewer ridges on the bloom's surface. Deep tears are more easily flared and as a result fill out better in later rolling. The fact that a poorly scarfed bloom is returned to the man responsible for additional work without bonus credit has reduced the desire to try to "slip one by." In final analysis, however, it is not the faster scarfing but better and faster handling that is responsible for the increased rate.

After nine months' operation of the new hot scarf facilities, certain weaknesses which were not of a limiting nature, was seen. The satisfactory results that have already been achieved will be surpassed once these weak points have been eliminated. It is no dream to say that this mechanical turner with its simplicity, ruggedness and inexpensive power may well make skin scarfing the best and most economical method of steel conditioning.

DISCUSSION

PRESENTED BY

R. L. DEILY, Steel Mill Representative, Air Reduction Sales Co., New York, N. Y.

J. J. KENNEY, Assistant Superintendent, Conditioning Dept., United States Steel Corp., Duquesne, Pa.

R. L. Deily: The application of improved materials handling methods to hand scarfing has produced such excellent results that we wonder a little why it was not done before. Possibly the inherent flexibility of the oxygen cutting processes is one of the reasons. For example, scarfing which came into widespread use during the 1930's was so readily done that it was only necessary to put a man on one end of a torch and a bloom on the other end. The scarfing operation was so much faster than hand chipping that the mill personnel were generally satisfied with its performance.

In contrast to this, mechanical chipping required

both adequate engineering of machines and of handling equipment in order to be done at all. When similar concepts of engineering design and materials handling are applied to the oxyacetylene torch, entirely new fields of application open up. Scarfing machines are an outstanding application of such design principles to oxyacetylene operations.

The subject paper describes an improvement which is in the direction of a completely mechanized scarfing operation. There still is manual handling of the torch for greater flexibility, while the materials handling is done on a semiautomatic basis. The first and most important benefit is that production per manhour has doubled and will probably improve further. Also, Mr. Glossbrenner states that there is an improvement in the quality of the scarfed surface. Finally, it has become easier for smoke to be removed from the scarfing area.

J. J. Kenney: I would like to know what type heating furnace you use to service these machines and the distance the heating furnaces are from the machines. I would also like to know how much smoke is created and whether it is necessary to install louvers in a large building.

A. B. Glossbrenner: The furnace is a 30 x 20 ft hydraulic pusher type either gas or oil-fired. There are eight burners on each side, four firing over the steel and four under. The furnace pressure is maintained at hearth level. The temperature is controlled in two zones. We are using dry skids made of seven 8-in. tubes with a 1-in. wall. This type skid has given us the least amount of trouble of any we have tried. We heat on a three to four-hour cycle up to 600 to 800 F depending on whether it is summer or winter.

The distance that the lift truck must travel from the furnace to the various turning machines varies from 10 to 30 feet. The hearth empties out in the midst of the four beds, two beds being on either side.

The high carbon steels are great smoke producers especially when scarfed with a large torch. We could not scarf this steel under these conditions without a provision for immediate smoke removal. I doubt that a standard high, well ventilated mill building would be able to dissipate the smoke fast enough to permit the hot scarfing of higher carbon pre-heated steel without proper exhaust facilities immediate to the scarfing locations.

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A New Concept in D-C Motor Design

By R. A. GEUDER
Manager Industry Sales
and
W. R. HOUGH
Engineering Vice President
Reliance Electric and Engineering Co.
Cleveland, Ohio

. . . . additional demands by industry for better motors are being met with new designs from the manufacturers . . . . quick response to load demand is an important requirement being set by industry, particularly for continuous production operations . . . .

▲ WHILE we are still in the "mechanical age," we are writing chapters of an "electrical age" superimposed upon the mechanical. What is happening and has been happening for a number of years is that ever-increasing production capacity has been demanded from machinery. The demand is evident not only in requirements for high-speed motors but also for wide speed ranges and high degrees of synchronization.

Industry today is demanding motors that can assume command of the job and produce rugged power to drive machinery—yet maintain precise control of the situation—a giant's strength with a feather touch. This combination adds up to the need for dynamic response, or instantaneous reaction to any demand for change.

Our company has been building direct-current motors for 50 years. Some 40 years ago we designed and introduced to industry an outstanding line of heavy-duty d-c machines. These machines incorporated not only the thinking of our engineers but the ideas of many operating engineers in heavy industry, particularly the steel industry. We are still building these motors. Present day motors are quite different from the model of 40 years ago—commutators, brush rigging, windings, material, bearings, and enclosures have been progressively improved. But the broad concept—the basic philosophy—has remained the same.

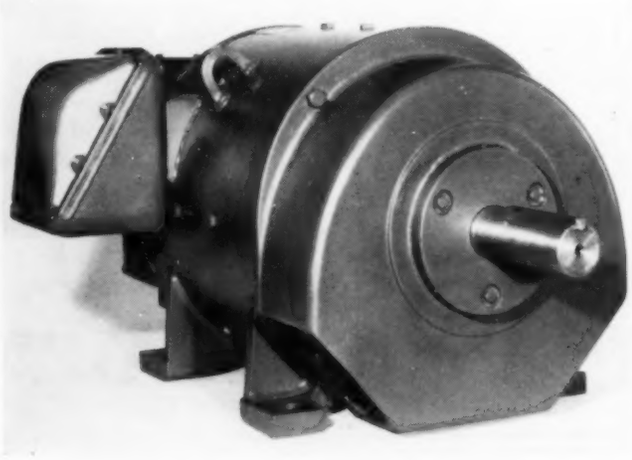
Over the years we have also designed and built an impressive number of special purpose d-c machines. In this activity when we were free to produce machines that embodied the optimum in design and material, such things as standardization and interchangeability could be disregarded. Most of the special machines were applied on the toughest applications and provided us with an excellent proving ground for new ideas and better techniques. This great backlog of experience made it increasingly clear that we could provide much better d-c machines.

A Look at the Past—Years ago, industrial equipment was operated by single-speed direct-current motors. In many operations the use of a single speed was not very practical or efficient, and it soon became evident that better results would be obtained if heavy work was done at low speeds and other work at higher speeds. For this reason, mechanically flux-weakened adjustable-speed d-c motors were introduced.

The next step in securing greater flexibility for motor drives was remote control which became quite desirable with more widespread use of adjustable speeds. This feature was afforded by electrical field-weakening control of adjustable-speed motors, producing a workhorse motor with a wide speed range for operation from constant-potential direct-current lines.

In the early 1930's, the trend was to accomplish with a-c motors all that had been done with d-c units. Multiple-speed motors, wound-rotor motors, slip clutches and hydraulic couplings, and many other devices were promoted vigorously. Enthusiasm was stimulated by the simplicity of the a-c motor and the ease of distributing a-c power, but any approach to adjustable

Figure 1 — New d-c motor design is of the fully protected type.



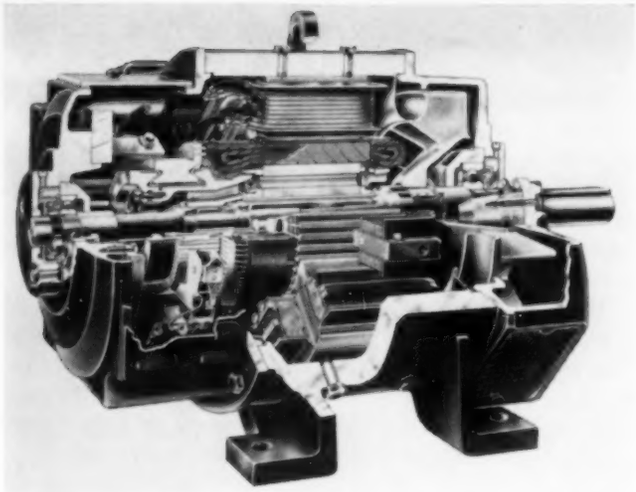


Figure 2 — Cutaway view shows details of motor design.

speed was still only second best to adjustable-speed d-c drives.

A Look to the Future—As machinery produces more, even more is demanded, as reflected by requirements for motors to afford higher speeds, wider speed ranges, and greater degrees of control and synchronization. High-speed machinery requires smooth starts and fast safety stops as well as smooth transitions between low and high speeds.

The steel industry, for instance, needs wide speed ranges so that heavy gage material can be handled at low speeds and lighter gages at higher speeds. Multi-motor processing line drives require precise synchronization of speeds throughout the process. Tandem drives with tension reels, pickling and tinning lines, and wire drawing operations are typical in their need for extremely accurate adjustable speeds with the ability to withstand momentary overloads.

Automation—The new field of automation promises to become increasingly important as greater numbers of companies seek greater production, higher quality and lower costs. Electrical "tools" such as the d-c motor bear the burden in automation because they produce accurate positioning, precise speed regulation, and controlled high and low operating speeds even while running under heavy loads or frequent overloads. These motors must have dynamic response—they must respond instantaneously to demands to change speed, reverse, and stop. Although this kind of performance is available only from a d-c motor, the ease, simplicity and economy of a-c power distribution are vital factors. What is demanded, then, is a d-c motor which can be supplied with power from on-the-spot conversion of a-c power to controlled d-c power.

A Standard "Package" — Dynamic response was pointed out as the controlled reaction of motors to the demand for a change—dynamic because it is powerful enough to move the loads, yet with controlled response to prevent damage to thin sheets. This dynamic response has been provided before, but only through special engineering for particular applications.

The goal was to combine all these characteristics into a standard industrial duty motor—a motor based on the concept that such requirements are becoming the normal rather than the unusual. Our new line of d-c motors are firmly based on this concept. See Figures 1 and 2.

Figure 3 — Space savings of new motor are illustrated by sketch.

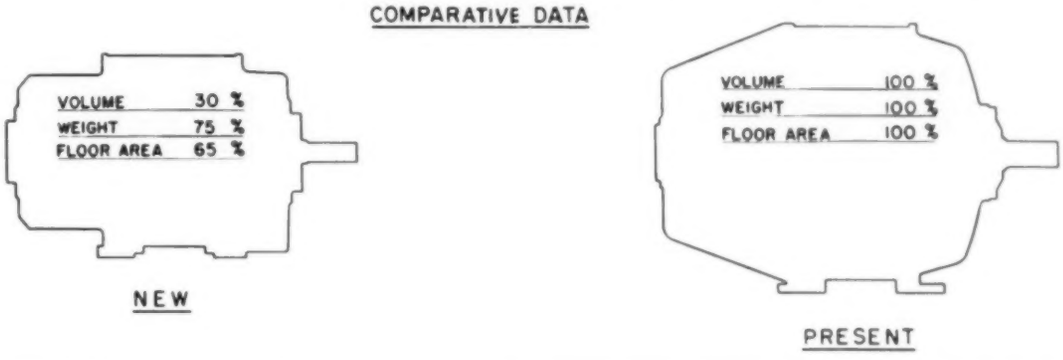


Figure 4 — Chart shows better acceleration characteristics of the motor.

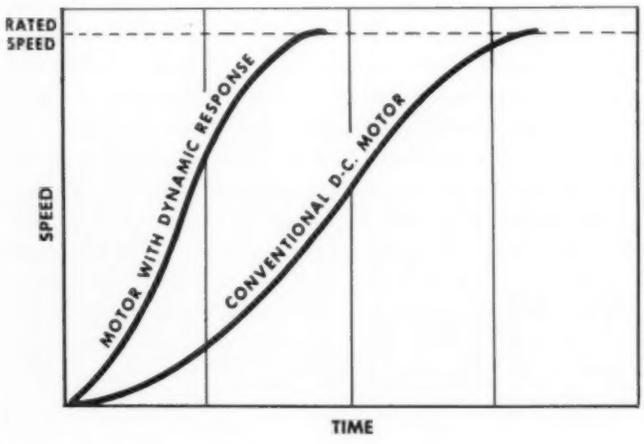
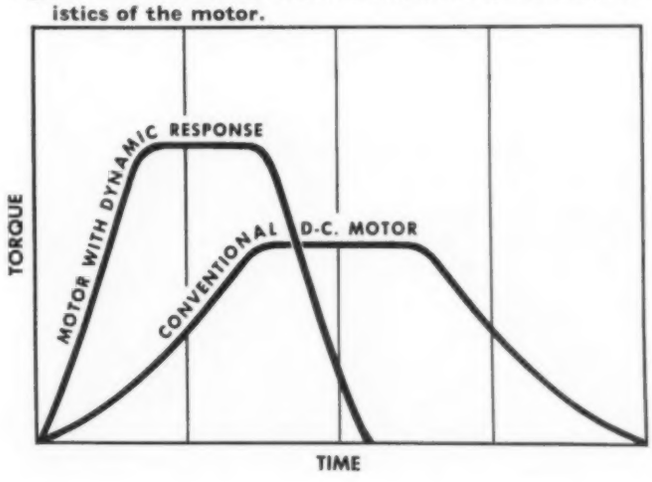


Figure 5 — Chart shows better available torque characteristics of the motor.



The goal was to combine all these characteristics into a standard industrial duty motor—a motor based on the concept that such requirements are becoming the normal rather than the unusual. Our new line of d-c motors are firmly based on this concept. See Figures 1 and 2.

Stored energy of the new motors has been decreased resulting in lowered resistance to changes. Fast electrical and magnetic circuits, high thermal capacity, and high maximum speed capabilities contribute to the dynamic response. High torque was secured through careful design, even though very small armature diameters were maintained. The dynamic response includes the ability to commutate high overloads and rapid load changes. A capability has been demonstrated to transform the urgent demands of driven machines into rapid, powerful response with continuous good commutation.

This design is a fully protected machine with a rated temperature rise of 60 C. With the incorporation of Class B insulation as standard—glass, mica, and new impregnating varnishes—a greater degree of safety is provided than previous motors rated at 50 C rise. This better insulation resulted in small diameters—both of the armature and the overall motor, Figure 3.

A typical example of response is the operation of a 250-hp direct-connected motor driving a flying shear in a steel mill. The shear repeatedly cuts bar stock traveling at 2200 fpm into 81-ft lengths within a ½-in. accuracy. The motor is started, accelerated precisely to full speed and is stopped, accelerated and repositioned in just 1.7 seconds, Figures 4 and 5.

The philosophy of dynamic response also applies to applications such as those in which delicate foils and thin sheets are processed at high speeds. Production must be brought up to and maintained at a high production level, but control must be precise to prevent breakage or stretching of the foils and sheets.

PRODUCTION AND PROPERTIES OF EXPERIMENTAL PELLET-SINTER*

▲ CURRENT investigation in the field of iron-ore agglomeration has been prompted largely by the limitations encountered in applying conventional sintering to finer ore materials, such as the concentrates produced from taconites and fine-grained New York ores. Among the techniques being studied as processes for fine-ore agglomeration are briquetting, nodulizing, vacuum extrusion, and pelletizing. This last method is receiving the most attention.

As originally conceived, the pelletizing process consisted of rolling the fine-ore concentrates and intermixed fuel into balls, which then were heat-hardened in a shaft furnace. Succeeding developments within the industry have modified the process, in that heat hardening on a sinter grate is now more generally preferred. E. W. Davis, of the University of Minnesota's Mines Experiment Station, demonstrated this method some years ago and recently Allis-Chalmers and the Arthur G. McKee Co. have cooperatively constructed a relatively large-scale sintering machine designed for pellet-hardening purposes. At least three pilot plants involving sinter-grate pelletizing have been, or are being, operated in this country, while abroad, Lurgi and associates have been very active.

This method of heat-hardening pellets, although employing a sintering apparatus, cannot be termed sintering in the sense commonly understood as iron-ore sintering. Sintering practice in the iron-ore industry usually supplies enough heat through combustion of fuel in the bed to fuse the ore particles into a cellular mass. The sintering-grate method of pellet hardening tends to keep each pellet intact and separated on the hearth during the process and the resulting product is similar to a pellet hardened in a shaft furnace.

The Ore Research Division of Jones and Laughlin's Research Department has been following closely the development of grate hardening of individual pellets in both field and laboratory investigations. In addition, considerable time has been devoted to the "sintering" of small pellets—a method in which features of sintering and pelletizing are combined to produce a unique, hybrid agglomerate called "pellet-sinter."

Interest in the possibility of sintering small pellets made from fine iron ores was keen, for several reasons. Theoretically, the small pellets should present a very porous bed, essential for a high production rate. Also, it was believed that making small balls would present less difficulty than making large balls. In addition, sintering machines are of good capacity as compared with vertical shaft furnaces and would be free of some of the operating difficulties. With respect to raw materials, conventional sintering machinery handles hematite as well as magnetite and it was expected that pellet-sintering would do the same.

For these reasons, a thorough program of pellet-sintering investigations was undertaken by the J&L Ore Research Division. It is the purpose of this paper to make available pertinent data obtained to date on production rates and the properties of "pellet-sinter."

A hybrid agglomerate termed "pellet-sinter" has been produced at an encouraging rate of production on an experimental basis. The general practice utilized a combination of the pelletizing and sintering processes.

Specific practice requires the production of small green pellets with a nominal top size of ⅜ in. Moisture content of the green balls must be carefully controlled to prevent production of excess oversize. Undersize material, likewise, is detrimental to optimum production rates. Using No. 6 mesh on the U.S. screen scale as a reference point, it was found that best production rates were obtained when all green balls less than that size were eliminated. Fuel may be coal or coke, mixed internally with the concentrates or rolled on the outer surface of the pellets. Particle size of the fuel need not be as small as the concentrate; No. 4 buckwheat anthracite culm has been used successfully.

It appears from work done to date that current sinter installations can be used for this method of agglomeration merely by installing a balling drum and accessory equipment. The crux of the process lies in the preparation of a green pellet of the proper size and containing the proper amounts of fuel and moisture. With such pellets, pellet-sinter of satisfactory quality can be produced on a sinter-type strand at an acceptable production rate.

*From paper by F. M. Hamilton and H. F. Ameon, Supervisor Agglomeration Research and Supervisor Information Research, respectively, Jones and Laughlin Steel Corp., Division of Ore Research, Negaunee, Mich., presented at Blast Furnace and Raw Materials Conference, Philadelphia, Pa., April 18, 1955.

Some Aspects of Open Hearth Waste Gas Analysis Control

F. P. HUBBELL
Superintendent Fuel Dept.
Homestead District Works
United States Steel Corp.
Munhall, Pa.

. . . . continuous waste gas analysis control is useful for the determination of open hearth combustion practice . . . . in a shop where operation of a number of furnaces is essentially alike, control can be applied to one furnace from which practice and schedules can be set up for all the furnace units . . . .

▲ IN the fall of 1951, a trial waste gas analysis control installation was made on a 225-ton basic open hearth furnace. This installation was designed to withdraw waste gases continuously from the furnace downtakes and pump the sample to an analyzing and control unit located at the furnace control board, a distance of approximately 150 ft. The control unit was provided with a control selector for desired oxygen content in the furnace waste gases and necessary interruption and sequence timers. The combustion air supply to the furnace, which is initially set by a fuel-air ratio control, was corrected by the waste gas analysis control to increase or decrease combustion air supply to the furnace until desired oxygen content of the waste gases is obtained. A standard two-point drag record electronic potentiometer for recording temperatures was modified to record oxygen and combustible content of the gases being analyzed.

This installation gave fairly good results; however, several rather severe problems were encountered and had to be solved.

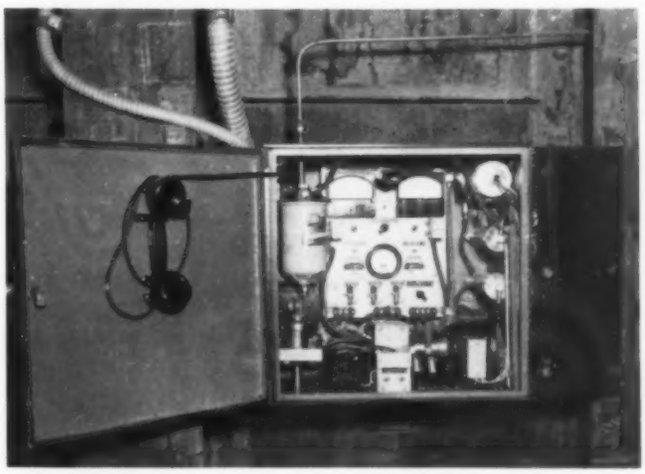
These problems were:

1. The long pumping lines involved in transferring the sample from the furnace downtakes to the analyzer created a sample-transfer lag of approximately 65 seconds.

2. To keep this sample-transfer lag to 65 seconds required pumping approximately five times the sample volume required for analyzing, with the excess being bled off at the analyzer. Handling this large sample volume caused considerable difficulty in the pumps, filters, and pumping lines.

3. Due to condensate formation in the long pumping lines, frequent purging with compressed air was required.

Figure 1 — An analyzer is used at each end of the open hearth furnace.



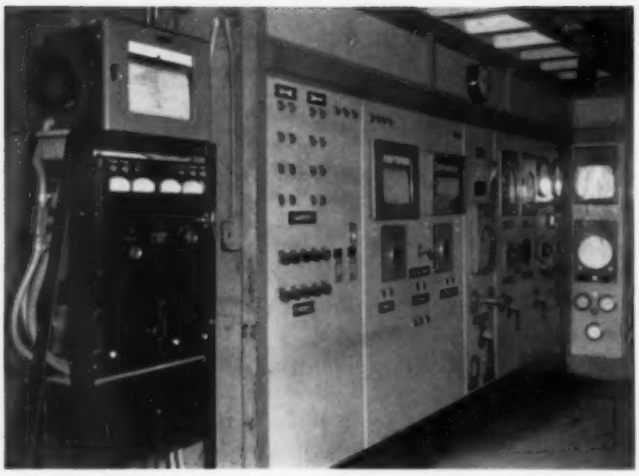


Figure 2 — Control unit has been completely revised from the original installation.

4. The pumps used to withdraw and pump the sample to the analyzer were not well suited for the application. Difficulties were experienced in plugging of the pumps and overloading of the pump motors, especially during cold-weather periods.

5. The analyzing unit required standardization every eight hours; the hydrogen cell required the addition of distilled water every three days.

After many months of experimentation with this installation, a new design was developed to eliminate the major unsatisfactory operating conditions and was recently placed in service. Two analyzing units, of the type shown in Figure 1, are used with this installation. These analyzers, one at each end of the furnace, are installed at cellar level and are sequenced to operate with furnace reversals. These units are provided with automatic standardization, which occurs at each furnace reversal, distilled water reservoirs for the hydrogen cells, heater and fan units to control ambient temperatures, and heavy-duty pump units, all encased in a heavy steel cabinet. A sixteen-wire cable for electrical impulse transmission is connected from each analyzer unit to a control unit located adjacent to the furnace control board. By analyzing the waste gases at the furnace ends, the sample-transfer lag was reduced to 35 seconds.

The control unit, shown in Figure 2, is a completely new design, and is provided with a control selector for desired oxygen content in the waste gases, indicating oxygen and combustible meters for each end of the furnace, necessary sequence timers, and signal lights to indicate analyzer standardization.

As in the initial installation, there is a two-point drag record electronic potentiometer for recording purposes. Figure 3 shows the recorder and type of record obtained. This recorder has a center zero and records oxygen values from center to the right of the chart, and combustible values from center to the left of the chart.

Experience to date has indicated that a waste gas analysis control applied to an open hearth furnace cannot give the type of control normally expected in the control of temperature, flow, pressure, etc. Many disturbing and constantly changing factors are present during the operation of an open hearth furnace which make precise control of waste gas analysis practically impossible. A list of these factors would include the following:

1. During the charging period, door openings, changes in furnace pressure, and rather sudden changes in fuel input create severe changes in waste gas analysis at such frequency and duration that the control can never make the necessary corrections to maintain desired oxygen content.

2. For the period from finish charge to hot metal, waste gas stratification becomes an influencing factor. The degree of stratification is dependent upon the amount of scrap and the minner in which it is charged.

3. At the hot-metal addition, reactions from charged materials enter the picture, and combustion-air volumes, as set by a straight fuel-air ratio control, must be substantially altered if desired waste gas analysis is to be maintained.

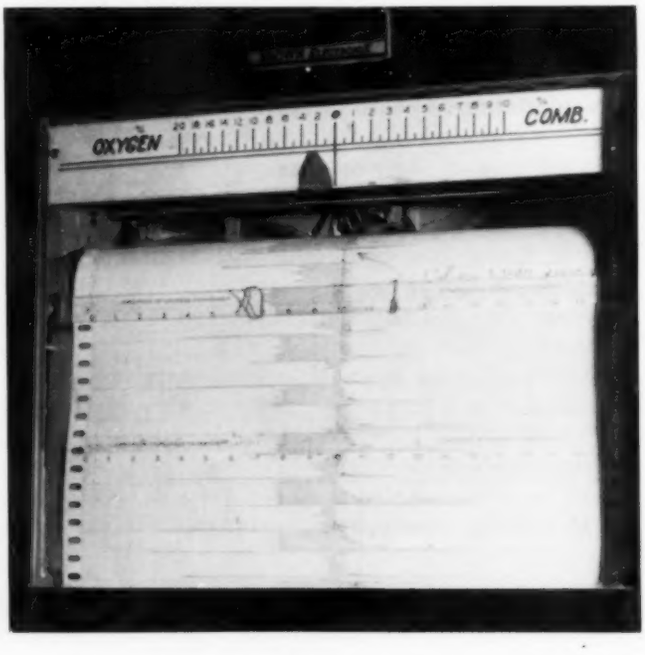
4. During the ore and lime-boil periods, the conditions encountered at the hot-metal addition are further amplified, and at times are of such magnitude that regardless of combustion-air input, it is impossible to burn completely the evolved gases in the laboratory of the furnace.

5. The period from melt to tap is generally considered the most suitable period for representative waste gas analysis. However, in striving for low tap-to-tap time, furnace operators have drastically reduced the melt-to-tap time and the available time for accurate control has thus been shortened. It has been found that in order to maintain from 1 to 2 per cent oxygen in the downtakes, combustion-air volumes of 30 per cent above theoretical are frequently required in the period from melt to tap, even though the bath visibly appears free of any significant reactions.

6. In the period from tap to start charge, changes in furnace pressure and door openings make waste gas analysis control difficult, if not impossible.

7. During all stages of the heat, furnace reversals are occurring at a frequency of eight to ten minutes. The waste gas analysis control may have just arrived

Figure 3 — Recorder shows oxygen values from center to right and combustible values from center to left.



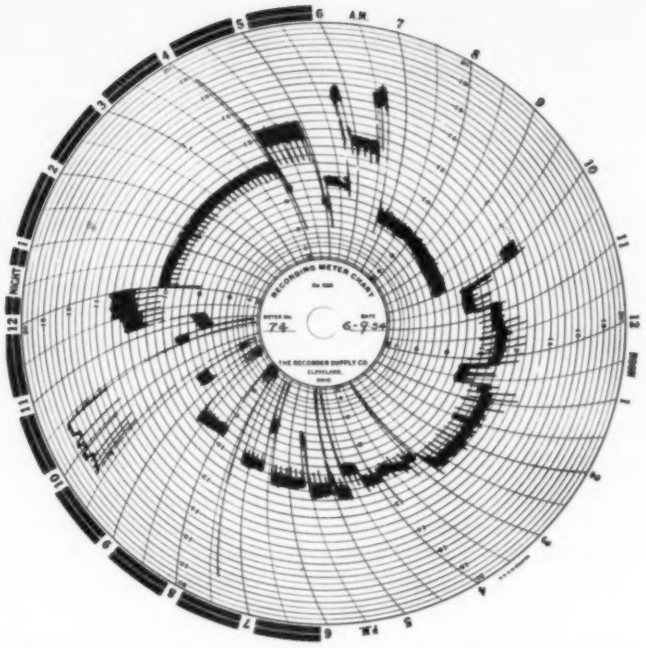


Figure 4 — Chart shows combustion air flow record when the air flow is set by the first helpers.

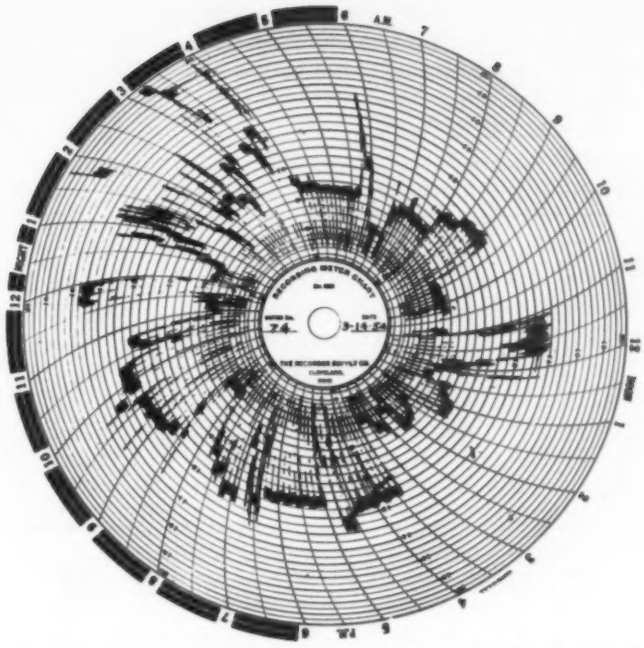


Figure 5 — Chart shows combustion air flow record when the air flow is set by waste gas analysis control.

at the proper air input when reversal occurs and new air settings will be required. Due to wide swings in waste gas analysis, which occur during and immediately following a furnace reversal, the combustion-air flow rate just prior to reversal, is automatically maintained for a period of two minutes from the start of a reversal. At the expiration of the two minutes the waste gas analysis control resumes control of combustion-air volumes.

In view of these rather severe problems listed here, the merits of any waste gas analysis control would appear rather doubtful. However, even though exacting control is not possible, it should be realized that regardless of the degree of control attained it is better than if no control had been exercised.

Figure 4 is a 24-hour combustion-air flow record from the furnace with the air flow being set by the first helpers. Settings were on the basis of judgment, not on waste gas analysis. Figure 5 is a 24-hour combustion air flow record from the furnace, with the air flow being set by the waste gas analysis control. These two records reflect little difference in total air usage for the 24-hour period, but do show the type of air-flow changes which occur when a waste gas analysis control is utilized.

The use of this waste gas analysis control has indicated that combustion air flows required during all stages of a heat are generally higher than those determined by means of spot Orsat analysis tests.

Following the installation of the improved control system, the control was in service for 95 per cent of the heats made on four of the first five furnace campaigns. During three of the campaigns on control, the combustion-air fan capacity was 1,200,000 cfhr. There were many times during the processing of a heat when the control unit utilized the maximum fan capacity, which was less than that required to maintain 1 to 2 per cent oxygen in the waste gases. Prior to the start of the fourth campaign on control, the fan capacity was increased to 1,700,000 cfhr by speeding up the combustion-air fan. This made sufficient air available at all times and frequently the control utilized maximum fan capacity.

While a comparison of furnace performance, by campaigns, using the 1,200,000 cfhr combustion-air fan, did not disclose any appreciable improvement in heat time or fuel cost per ton as a direct result of the control, apparently favorable results were obtained during the one campaign when the control and higher capacity fan were available. However, further study must be made before any definite conclusions are reached.

For all furnace campaigns where the control was used, a substantial improvement in roof life occurred. This is believed to be a direct result of higher combustion-air usage during the bath reaction periods, as dictated by the waste gas analysis control.

If sufficient air is made available at all times to maintain an oxidizing atmosphere in contact with silica brick, at the elevated temperatures encountered in an open hearth furnace roof, refractory life is substantially improved beyond that obtained when heavy reducing atmosphere conditions exist. This can be accomplished in two ways: one of which is by raising the furnace roof, resulting in an increased combustion chamber, which by the contours of the furnace will cause a blanket of combustion-air to pass through the furnace in contact with the roof without involvement in the combustion process. This type of furnace construction usually gives good roof life but leads to long heat time and high fuel costs. The alternate method is to utilize a roof height more conducive to good heat time and fuel costs and provide just enough combustion-air to maintain an oxidizing atmosphere against the furnace roof. This requires a rather delicate balance between combustion-air requirements and usage and would appear to be a strong argument in favor of a waste gas analysis control.

Additional experience will be required, but results

to date indicate that improved furnace refractory life may be the major benefit derived from control of waste gas analysis and should be considered one of the major economic factors in determining the value of such a control.

In view of the facts presented here, it is the opinion of the author that a continuous waste gas analysis control will function within certain limits and is very useful for determination of open hearth combustion practices. It is recognized that if all factors pertinent to good open hearth furnace operations are investigated and controlled, a control unit of this type may not be required or particularly desirable on all furnaces. However, if a control of this type is applied to one typical furnace in an open hearth shop, much useful information can be obtained which will assist materially in establishing sound combustion practices.

DISCUSSION

PRESENTED BY

E. T. W. BAILEY, Chief Combustion Engineer, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

JOHN R. GREEN, Metals Producing Industry Manager, Brown Instrument Div., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

J. G. SPARKS, Industrial Marketing, Cities Service Oil Co., Chicago, Ill.

F. P. HUBBELL, Superintendent Fuel Dept., Homestead District Works, United States Steel Corp., Munhall, Pa.

E. T. W. Bailey: I think we will all agree that Mr. Hubbell is under no delusions concerning the difficulties that beset attempts to evolve a practical waste gas analysis control for open hearth use.

Perhaps the author would indicate why he analyzes combustibles? Does this play any part in combustion control corrections? If not, what useful purpose does it serve?

The difficulties outlined during charging should be greatly reduced if the furnace pressure control was functioning properly. With atmospheric pressure at the floor plate line, waste gases should emerge through the open doors.

I am interested in the author's remarks about waste gas stratification during the period of finish charge to hot metal. We have never been able to detect stratification as the flow is very turbulent during this period. Perhaps he could elaborate on this item?

At the time of hot metal addition, one should expect the most use from combustion control setting correction. The operator could simply reduce the fuel flow and let the combustion control take over the air adjustment entirely. Of course, the forced draft fan should have ample capacity.

The author states "even though exacting control is not possible, it should be realized that regardless of the degree of control attained, it is better than if no control had been exercised." We are expecting a man to adjust combustion conditions in a furnace to hold an optimum waste gas analysis with no other yardstick than his eye. Progress will include such devices as the author describes as a means to aid operators achieve more efficient process conditions. The combustion control has been slow gaining favor in open hearth shops but as its flexibility is improved, progressive companies will eventually adopt them as standard equipment.

Our short experiences with continuous waste gas analyses confirms the author's statement that combustion air flows required during all stages of a heat are generally higher than those determined by means of spot Orsat tests. We also agree that the amount of excess oxygen in the waste gases that will give the best results is yet unknown.

The author closes on a somewhat pessimistic note. If the control arrangement he describes is good for one furnace it should be applied to all. This is, of course, after its real merit has been unquestionably established. Which brings us to the inevitable question, can he, as yet, all other factors being equal, say how many additional tons per hour can be realized over a year by the use of open hearth waste gas analysis control?

John R. Green: Valuable operating data on oxygen analysis and control has again been contributed by the author, based upon the Homestead installation.

Apparently, the initial sampling difficulties have been largely overcome, and the time lag of stable measurement after reversal has been cut in half by the use of individual analysis units at each end of the furnace.

It is suggested that a faster acting, but stabilizing proportional method of resetting fuel-air ratio from the oxygen measurement could more rapidly produce the combustion conditions desired during these short reversal periods.

This might reasonably lead to better fuel rates, as well as the savings reported to date in roof refractories.

In view of the recent studies made on efficiencies of regenerative furnaces, indicating that the burning of combustibles in the regenerators can be helpful in many cases, have any attempts been made at Homestead to control from oxygen analysis taken at the exit rather than entrance to the checker chambers?

J. G. Sparks: Have you had and have you been able to overcome sampling difficulties with sampling pipes, and the like?

I am also of the opinion that the open hearth is the acid test on any control. Realizing your position at Homestead, have you exploited or explored the possibility of giving this control to operators other than open hearth, possibly boilers, and the like?

Another question foremost in my mind is in the length of time you have experimented and worked with this control, has the information you derived been of an economical benefit to the corporation?

If we are to assume that furnace control is not practical, I am wondering if some of the books that have been written on per cent of oxygen in open hearth furnaces have not been written on assumptions, because if control is spotty and not reliable at those times when the furnace is in normal operation than are present data and books written on excess oxygen in open hearth furnaces to be believed or are they in the field of speculation?

F. P. Hubbell: To answer Mr. Bailey's question:

"Why do we analyze combustibles in the waste gases and does this play any part in combustion control corrections," combustion control corrections are made from oxygen content in the waste gases only. However, we do feel that an indication or record of the combustible content in the waste gases is helpful in adaptation of this control. A good example of this is when a heavy ore or lime boil action is occurring only at the last door from the firing end of the furnace. Gas evolution is often of such magnitude that it is impossible to supply sufficient air to the firing end of the furnace to completely burn these gases before they are drawn down past the sampling point in the uptake. When this occurs, very little if any oxygen is present in the waste gas sample withdrawn from the furnace and the control keeps increasing combustion air to the furnace in an attempt to correct this condition. If the only records available are combustion air flow and oxygen content of the waste gases, one would believe that the analyzing part of the control system was not functioning properly, which is not the case. When the furnace reverses its firing direction this heavy gas evolution will be on the firing end and these gases will be burned over the bath before reaching the downtake on the other end of the furnace, causing the control to cut back on combustion air input to the furnace. By having a record of the combustibles in the waste gases it is much easier to understand what is happening in the furnace at any given time.

With reference to waste gas stratification during the period from finish charge to hot metal, we do not have any correlated data to prove that it occurs, but our observations have been that the type and volume of scrap and the manner in which it is charged will often give erratic results in waste gas analysis during the meltdown period. Therefore, we feel that during the meltdown period the combustion information we get is not as reliable as it should be.

In regard to applying a combustion control to all furnaces in an open hearth shop, it is our belief that this is not necessary. If good standardized open hearth practices, such as furnace rebuilds, checker and flue blowing, charging, and hot metal delivery, are developed and maintained, a standard fuel firing practice by heat stage can be developed. A combustion control of the type discussed here applied to one typical furnace will provide sufficient information to establish manual combustion air settings by heat stage, which will approximate exacting air requirements, and can easily be applied to other furnaces.

As far as additional tons per hour as a result of this control, I cannot give you any figures. However, as indicated in the paper, this control very definitely pointed out to us what our combustion air usage should be and our practice was revised all over the shop. This has resulted in a rather favorable increase in furnace roof life which can be reflected in increased tons per hour coming out of the furnaces.

To answer Mr. Green's questions, we agree that a proportioning control probably would get us back to control point quicker than the present method employed and its application should be investigated. With reference to the sampling point used for oxygen content control, we have never attempted any point other than the furnace downtakes. The farther you get away from the laboratory of the furnace, the more the chances of picking up air infiltration which distorts the waste gas sample. It is impossible to completely eliminate air infiltration and the amount does not remain constant. Every time a furnace is cooled down for a hot work job air infiltration increases materially and it takes time to get this back to a minimum by sealing. For these reasons, we feel we should keep our sampling point as close to the laboratory of the furnace as possible, even though it does introduce other problems.

To answer Mr. Spark's questions, we have not overcome sampling difficulties. Our maintenance is averaging 8 to 10 hours per week on this installation. The principal maintenance requirements are changing filters and cleaning pumps.

We have not applied this control on other types of heating equipment in the mill, however, we believe that it could be very easily accomplished in comparison to the problems presented in the open hearth.

1955 AISE

ANNUAL CONVENTION

SEPTEMBER 26, 27, 28, 29

HOTEL SHERMAN **CHICAGO, ILL.**

THE 11-IN. ROD MILL

at Jones and Laughlin's Aliquippa Plant

By N. A. HANSEN

Superintendent Rod and Wire Dept., Jones and Laughlin Steel Corp., Aliquippa, Pa.

. . . . the new Aliquippa rod mill is an example of the modern trend in rod mill operation . . . . unit is designed for three-strand operation at speeds up to 6400 fpm . . . . design is also so set up that larger sizes leave mill at end of intermediate train . . . .

▲ PRIOR to the installation of the new rod mill at Aliquippa, there were two 16-stand straightaway rod mills of 1910-1911 vintage. These mills were driven by cross-compound steam engines rated at 2500 hp each. These mills differed from the modern rod mills we see or visualize today in that each one was mechanically connected from the first roughing stand through to the last finishing stand. Motive power was applied only in one place, the roughing train being geared direct to the engine with the finishing train being driven through a set of belts running on the fly-wheel of the engine. There were no loops or speed adjustments for section control, and only one size billet could be used practically. The finishing speed for 0.218-in. rod was approximately 3400 fpm, and with two strands of steel running through the mill, the average hourly production was approximately 22 tons per hour for each mill.

The initial appropriation for the new rod mill was granted July 6, 1950. The site selected for the new mill was where four batteries of old bee-hive coke ovens were located and it was necessary to remove two of these old batteries complete to provide ample room for the new mill together with billet yard and auxiliary buildings. Clearing ground was started October 23, 1950 and one of the outstanding feats of clearing ground was the falling of a 200-ft stack without damage to surrounding equipment. Ground was broken February 12, 1951 and the construction program was underway. The usual obstacles were encountered such as water, hot slag fills and caveins during excavation and, of course, the usual delays in material procurement, etc. One of the outstanding feats in the construction was the erection of steel for the main mill building including motor room, 125 x 500 ft, billet yard, 111 x 425 ft, roll shop and bearing shop, 75 x 200 ft, all of which was erected in less than eight weeks. To give you an idea of the magnitude of the construction project, there was over 34,000 cu yd of excavations; over 17,000 cu yd of concrete poured; over 1000 tons of reinforcing steel used; over 50 miles of conduit laid and over ¾ million manhours consumed.

However, after many trials and tribulations, the first rolling was made December 30, 1951. After this first rolling came the adjustment period, ironing out kinks, breaking in crews, etc., but taking everything into consideration the mill attained rated production in a relatively short time.

On Figure 1 is a general layout of the mill and the following description will follow the material flow line.

Raw material, 2½ x 2½ in. x 30-ft billets weighing approximately 600 lb are delivered to the billet yard in railroad cars. Chain slings are around each lift to speed handling and reduce labor costs. The billet yard has a storage capacity of approximately 15,000 net tons and is served by two 15-ton cranes. An unusual feature of these cranes is that the cab travels with the trolley which makes for a safe, economical operation.

Billets for rolling are placed on a billet separator by the crane. The billet separator separates and alines the billets and deposits same on roller table, roller tables carry the billets to charging position in front of furnace. Provision is made for rejecting billets from roller table

for any reason. The furnace pusher is of the rack and pinion type. One man operates billet separator, roller tables, reject rack and furnace pusher.

From the roller table, billets are charged into a two-zone suspended roof-type furnace with an effective heating length of 60 ft. Heating media is natural and/or by-product coke oven gas. Furnace hearth temperature is approximately 2150 to 2300 F. Furnace is equipped with the latest in control equipment.

From the furnace, the billets are charged or pushed into the first roughing stand rolls by means of a peel bar and pinch rolls. Between the furnace and No. 1 stand are located: (1) a set of driven pinch rolls—purpose of same being to return billets to furnace or aid in pushing billets into first set of rolls, particularly if passes are new and slippery; (2) a hydraulically operated switch—this being a 3-strand mill it is necessary to direct the billets into proper pass lines; (3) safety shear to shear billet in case of cobble in the roughing train.

The roughing train consists of eight stands (two 16-in. and six 15-in.) in line being driven in pairs by four 500-hp 300/900-rpm motors. The 16-in. stands are fitted with 28-in. face x 17-in. diam rolls and the 15-in. stands with 28-in. face x 16-in. diam rolls. Passes are alternately diamond and square with the billet entering the first pass on the diagonal. Cast iron guides are used in the roughing train. Roller twist guides are used to turn up the diamond. Hanging delivery guides are used for the squares. Stands are mounted on sliding bases to permit shifting of stands to maintain constant pass line. Shifting is accomplished through use of hydraulic cylinders.

After leaving the last roughing stand the front end of the stock is cropped before entering the first intermediate stand. This cropping is accomplished by an electrically operated flying shear. Positioning and operation of this shear is automatic, this being accomplished through use of photo-electric cells and relays. Length of cut or crop is adjustable. In case of cobble, the shear can be operated manually and will cut stock into approximately 3-ft lengths which drop into scrap box, eliminating long tangled scrap normally encountered.

The intermediate train consists of eight 12-in. stands driven in pairs by four 800-hp, 300/900-rpm motors. Stands are fitted with 26-in. face x 13-in. diam rolls. Passes are alternately oval and square. Cast iron guides are used in intermediate train with roller twist guides being used to turn up the oval. Stands here again, as in roughing train, are mounted on sliding bases to maintain constant pass line. There are two 180-degree repeaters in the intermediate train, namely, between No. 12 and 13 stands and between No. 14 and 15 stands. There is also a 180-degree repeater between No. 16 and 17 stands.

The finishing train consists of six 11-in. stands, numbers 17 through 22, driven by one 2000-hp, 300/900-rpm motor. Rolls are 20-in. face x 11½-in. diam. Passes are alternately oval and square. Bronze guides are used in the finishing train. Finishing speeds on 0.218-in. rod average approximately 5000 fpm with a maximum speed of 6400 fpm.

After leaving the finishing train, the finished rod

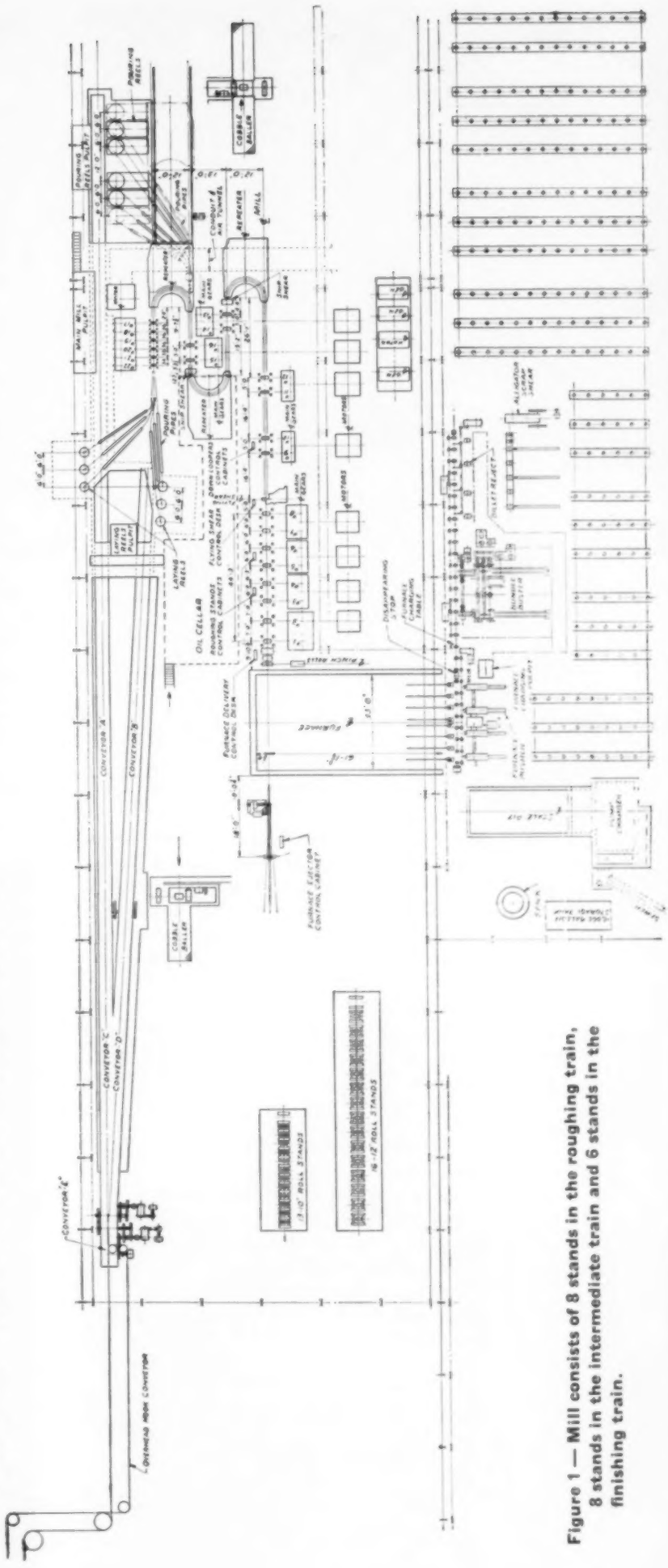


Figure 1 — Mill consists of 8 stands in the roughing train, 8 stands in the intermediate train and 6 stands in the finishing train.

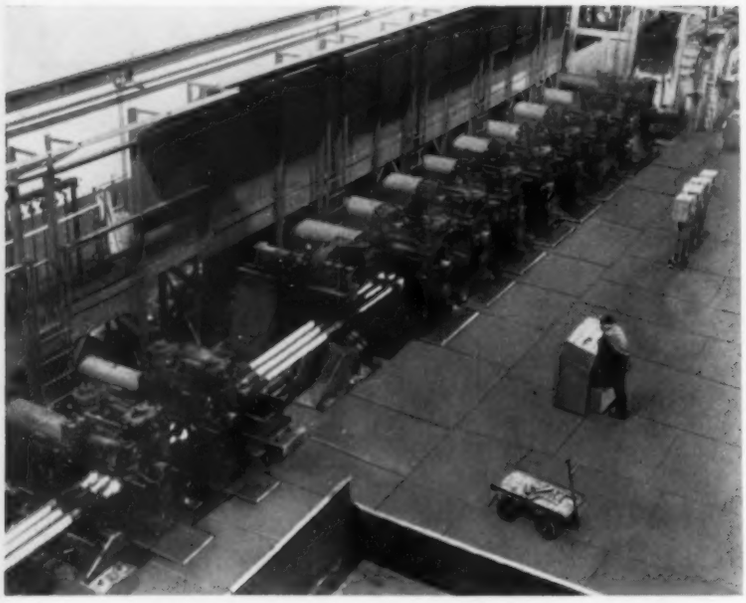


Figure 2 — Mill is designed for 3-strand operation. Rod is processed at speeds up to 6400 fpm maximum.

travels through a set of lead pipes through cooling trough and into laying reels. In order to maintain continuous three-strand operation, it is necessary to have six reels and switch a given strand of finished rod from one reel to another. This switching is accomplished through use of an air cylinder actuated by a photoelectric cell.

Rod size 0.218 to $^{11}/_{32}$-in. are finished on the finishing train while rods $^{23}/_{64}$ to $^{21}/_{32}$-in. are finished on the intermediate train and delivered to any of six pouring reels.

Finished coils are pushed onto drag conveyors which carry the finished material to the north end of building, approximately 400 ft, where the coils are transferred to a hook conveyor. Just north of the main mill building is the inspection station where material is trimmed, inspected, tested and identified by heat, size and grade.

The hook conveyor carries the finished material to the old rod mill warehouse, a distance of well over 1000 ft. Here the material is automatically unloaded and accumulated in "lifts" for tractor or crane handling.

MILL ACCESSORIES

1. All rolling stands are equipped with top and bottom roll adjustment and hydraulic roll separation.
2. All roll necks are fitted with anti-friction radial and thrust bearings with automatic grease lubrication.
3. All stands are driven through gear-type couplings.
4. Snip shears are located ahead of stands No. 13, 15 and 17. Purpose of these is to keep scrap in the mill to a minimum in case of cobble. These shears can be operated from the main mill pulpit or from the floor.

MILL AUXILIARIES

1. Mill crane—one 15-ton crane with 5-ton auxiliary hoist.
2. Two cobble ballers strategically located for handling cobbles and trimming scrap.
3. Thirty set-up stands to expedite changes. All roll changes are made on the set-up floor so that in making roll change for size or replacement in the mill, complete stands are changed.
4. Oil cellars for mill lubricating and hydraulic systems. There are three circulating oil systems, namely, one system for the roughing and intermediate drives; one system for the finishing drive and auxiliary equipment and one system for motors. There are two automatic grease systems—one system for roughing mill roll bearings together with auxiliary equipment and one system for the intermediate and finishing train roll bearings. There are two hydraulic systems, namely, one system for hydraulic roll separation and one system for auxiliary equipment.
5. Scale pit is 15 ft wide, 34 ft long and 37 ft deep to take care of mill scale sewers. Scale pit is designed to prevent any oil or grease from getting into sewers. Elevation is below river elevation making it necessary to pump water from scale pit to sewers.
6. Air conditioned motor room houses all drive motors (with the exception of 2000-hp finishing train motor which is out in mill), motor-generator sets, rectifiers, controls, meters, etc.
7. Mill pulpit contains all mill drive controls. Operator can alter speed of any pair of roughing or intermediate stands. He can alter speeds of roughing, intermediate or finishing trains individually or collectively.

Figure 3 — Rods from 0.218-in. to $^{11}/_{32}$-in. are finished on the finishing train and rods from $^{23}/_{64}$-in. to $^{21}/_{32}$-in. are finished on the intermediate train.

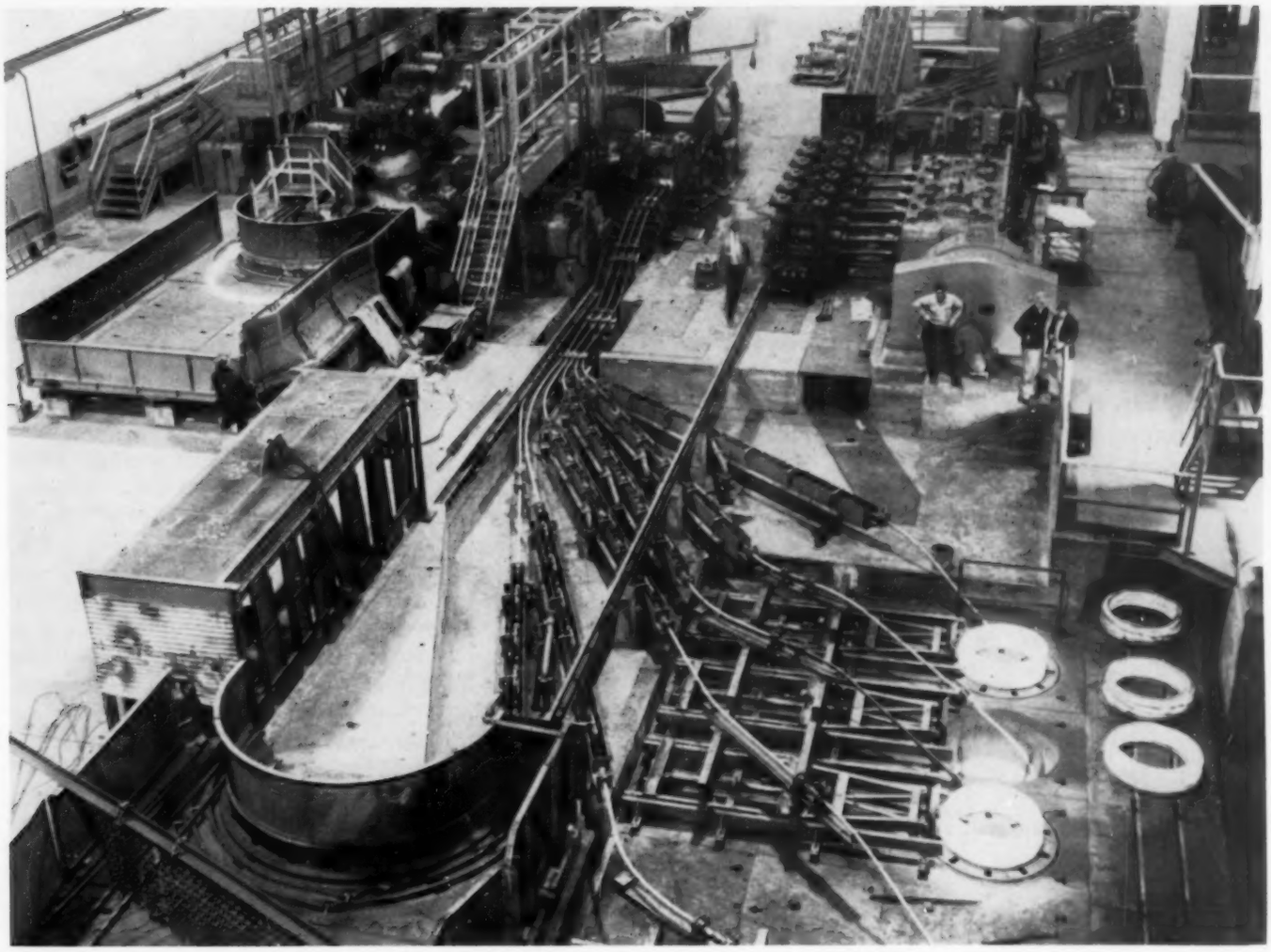


Figure 4 — To maintain 3-strand operation, 6 pouring reels are used and rods are shifted by means of an air cylinder from one reel to another.

There are vernier controls on the mill floor for making minor speed adjustments to the roughing train.

8. Operator can adjust speed of any or all reels to suit operating conditions. Normally, once set, reels follow speed of finishing stand. Dumping and pushing is set up automatically but requires some attention.

9. Guide shop is used for grinding and servicing of guides.

10. Bearing shop is used for removal and placing of bearings on roll necks, repair, servicing and inspection of bearings.

11. Roll shop services rolls. Equipment consists of one roll grinder, one contour roll lathe, three roll lathes and template shop.

GENERAL

Mill performance has met all specifications as to production and quality.

Some production figures are:

1. Average hourly production—41.28 net tons per gross operating hour (includes all roll changes, pass changes, size changes and all other delays).

2. Daily production record—1180 net tons with three changes.

3. Turn production record—491 net tons.

4. Monthly production record — 24,530 net tons. Maximum capacity at time of writing this report has not been attained due to business conditions.

Some quality items are:

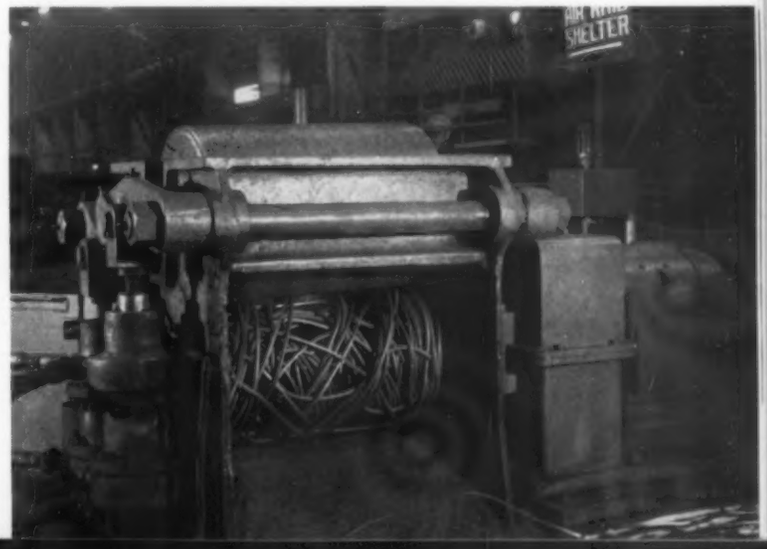
1. Average yield is in excess of 95 per cent.

2. Very close tolerances attained average plus or minus 0.005 in.

3. Rejections for steel defects and section run well below 1 per cent.

4. Up-set rejections on cold heading grades for both steel and mill defects average about 5 per cent.

Figure 5 — Two cobble ballers are strategically located for handling cobbles and trimming scrap.



DISCUSSION

PRESENTED BY

D. W. McLEAN, Assistant Superintendent Rod and Bar Mills, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

N. A. HANSEN, Superintendent Rod and Wire Dept., Jones and Laughlin Steel Corp., Aliquippa, Pa.

EDWARD C. PETERSON, Engineer, Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.

CHARLES H. BURDEN, Chief Project Engineer, John A. Roebling's Sons Corp., Trenton, N. J.

ANDREW WILSON, Assistant Roll Designer, United Engineering and Foundry Co., Pittsburgh, Pa.

D. W. McLean: There are two or three things about which I would like to ask. One, what do you mean by 0.005 plus or minus? Is that out of round, over and under size, or just what do you mean by that?

Secondly, and closely connected with that, what variations do you get in your motor speeds; two per cent, one per cent, half a per cent?

On your cold heading, you said you had 5 per cent reject. I would like to know how much testing you do. In other words, do you test one in five, one in two? On the 5 per cent reject, is that from billet to finished coil or finished coil to shipped weight of coil, or billet weight to shipped weight?

N. A. Hansen: When I say plus or minus 0.005 in., for instance, we roll our 0.218-in. rod at 0.220 to 0.230 in. and it very seldom runs 0.005 in. out-of-round.

On the speed, I presume you have reference to variation in motor speed, from no strand to three strands. We notice a little bit of speed up in our roughing train as the strands drop out, particularly when we are rolling the larger sizes and we are not keeping the mill full. In other words, the loop between No. 8 stand and No. 9 will grow on the tail end of the last billet.

On cold heading, percentage given is from coil as rolled to the stocking into the cleaning house or shipped.

As far as testing is concerned, we upset both ends of every coil.

E. C. Peterson: Mr. Hansen has very ably covered the outstanding features of a notable addition to the country's rod producing facilities. I have just two questions I would like to ask him about the information he has given. First, what was the size being rolled when the production of 491 tons was made? If it was not No. 5 rod, what is the maximum production that has been made when rolling No. 5 rod?

Secondly, I notice that this mill has the roughing train stands driven in groups of two as opposed to so many other mills which have more than two stands on one drive. I would like to know if Mr. Hansen feels, now that he has had experience with this type of mill, that this grouping presents definite advantages and, if so, why?

Rod mill stands and their arrangements, in this country, show relatively minor variations. Such variations as there are from mill to mill may have relatively little effect on the over-all mill performance. With heavier coils being produced at higher cyclic rates than ever before, a real materials handling problem arises. It is in this field that there are more significant variations to be found in the mill equipment.

An interesting solution to this problem is shown in Figure 6 which shows six coilers grouped around and delivering to a central point. This is a shop assembly picture, and the short section of conveyors shown is actually extended for several hundred feet in the completed installation. Stripping and push out are accomplished hydraulically. All of these motions are electrically interlocked to avoid any possible collision between coils.

All operations, from switching three strands in the guide pipes to assembly of the coils on a rotating bundle holder are accomplished automatically.

The arrangement of the equipment is shown in Figure 7. The apron conveyor moves once for every coil that is put on it, as does the hook conveyor. Every time the conveyor moves, it loads one hook on the hook conveyor. Thus every space on the apron conveyor and hook conveyor are filled at all times giving maximum efficiency.

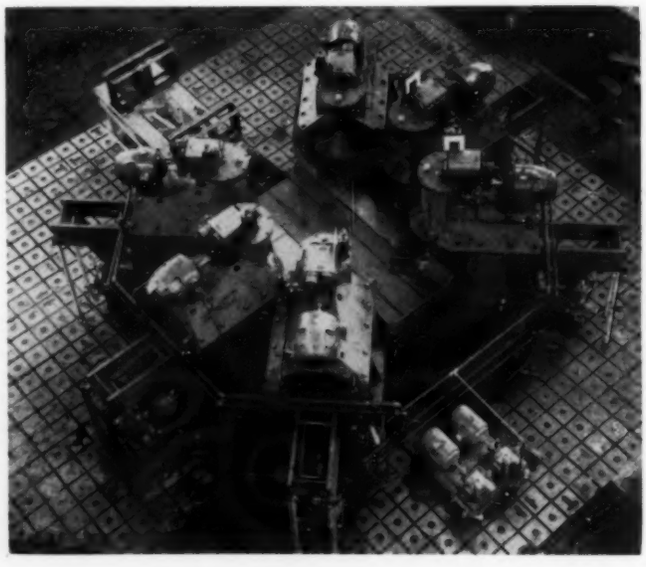
Unloading is done automatically and the coils are grouped for removal by an overhead crane.

A tying station for tying the coils before being loaded on the hook conveyor, is provided in the apron conveyor.

Because of the simplicity of this arrangement, with only one apron conveyor, it requires a minimum of installation cost, space, and maintenance.

Mr. Hansen also mentioned that all of the stands in the A-2 mill are mounted on anti-friction bearings. Usually this type of bearing involves the use of a tapered bore, and then, of course, the neck must be tapered. The question often arises as to how to turn the rolls for redressing. Centers may be left in the roll on which it can be mounted for redressing. But there is always a possibility that the centers will not be con-

Figure 6 — Six coilers are grouped so as to deliver to a central point.



centric with the neck, in which case the finished grooves will not be concentric with the neck.

A recent bar mill installation which specified very close bar tolerances also had all the necks on anti-friction bearings, and a roll lathe was furnished with this installation which was arranged to turn the finishing rolls directly in the roll chucks. In this way, the prime requirement for concentricity was assured, and in addition, since it is not necessary to remove the roll chucks for turning, labor cost is saved and the possibility of damage to neck bearings and seals is reduced.

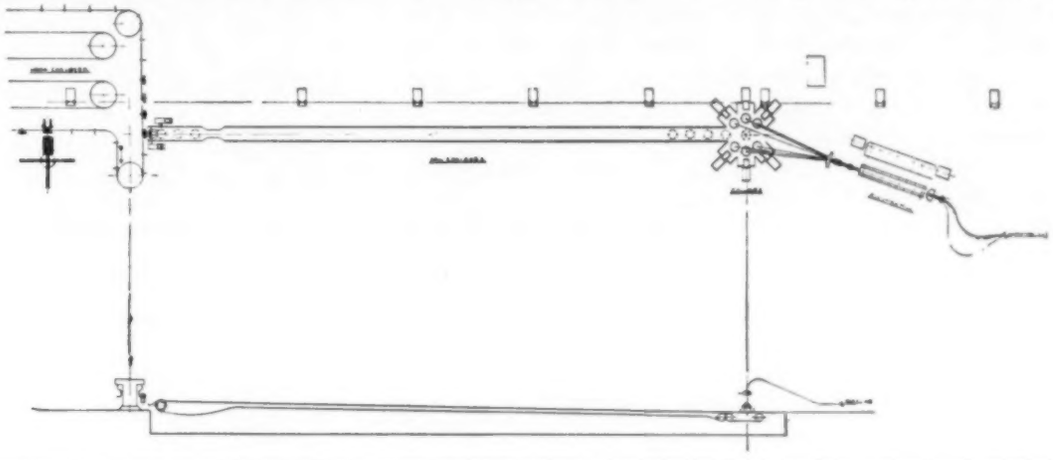


Figure 7 — Every-time conveyor moves it loads one hook on the hook conveyor.

This lathe is shown in Figure 8; it has special provision for taking the play out of the bearings during the roll turning operation. There is a central head stock with a face plate on each side. Each of the face plates is driven by two helical pinions, which reduces the tooth load and reduces vibration.

On the left-hand side, as shown, the lathe is set up for turning the roughing mill rolls which have straight necks and is arranged in the conventional fashion. The other side of the lathe is arranged for turning rolls in the mill chucks as described.

N. A. Hansen: In answer to the questions, the turn record of 491 tons was made on $\frac{9}{16}$-in. rod. The turn record for 0.218 in. is 415 tons.

As far as driving the roughing train in pairs, we feel it has very definite advantages. One, we can eliminate pull in the mill to a very large degree. Secondly, we do not have to match our rolls as closely, as we do not have to match six pairs of rolls—only two.

Charles H. Burden: Does the mill have any descaling devices in the layout? Do the pinch rolls do any descaling, or is any high pressure water used anywhere along the mill specifically for descaling purposes?

Are both the entry and delivery guides in all six of the finishing stands made of bronze, and are these guides all ground in a precision grinder or are they ground off-hand?

N. A. Hansen: As far as descaling, we do not have any high pressure water for descaling, as such. We do have some descaling equipment—if you want to call it that—between the rolls and the finishing stand. On 0.218-in. rod we will finish around 1800 or 1850 F and we will cool that rod down to about 1550 or 1575 F before it gets into the reels.

As far as the bronze guides are concerned, we use bronze entry and delivery guides and they are ground in the guide shop on a guide grinder. However, if you know rollers and finishers, you can never grind a guide to suit them. We started out and were not even going to put a grinder on the mill floor, to avoid that very thing, but we found them running back to the guide shop to grind them—so we figured we might as well put the grinder out in the middle of the floor and save time.

Andrew Wilson: The method of getting rods out of this mill is very unique. See Figure 1. The No. 5 rod is of course finished in No. 22 stand. In order to finish larger rods, it is only necessary to remove two stands at a time in the six stand finishing train. By this method, rods from No. 5 to $1\frac{1}{32}$-in. can be rolled with very little downtime for changing from size to size.

Rod sizes $\frac{3}{8}$ to $2\frac{3}{32}$-in. are finished out of No. 15 or No. 16 stand. A sixteen pass schedule is used for $\frac{3}{8}$ to $\frac{7}{16}$-in. at which point two stands are removed and two installed. These last two are the lead oval and finisher. The remainder of the mill is not touched. From $\frac{9}{16}$ to $2\frac{3}{32}$-in. two more stands are removed making a twelve pass schedule.

The roughing train stands No. 1 to 8 remain the same for No. 5 to $2\frac{3}{32}$-in. For rod sizes up to $\frac{7}{8}$-in. diameter, it is necessary to remove No. 7 and 8 stands and move 3, 4, 5, 6 to the position of 5, 6, 7, 8. For rod sizes up to $1\frac{1}{8}$-in. it is necessary to remove 5, 6, 7, 8 and move stands No. 3 and 4 to the position of No. 7 and 8.

By moving these stands forward, a larger square size is obtained which is necessary to make the larger round sizes. In addition to this, the tonnage is maintained due to the constant volume out of No. 8 stand.

In moving these stands, rolls and guides move as a unit. It is not necessary to remove this type of equipment from the stands.

Figure 8 — Left hand side of lathe is shown set up for turning roughing mill rolls with straight necks in the conventional fashion. Right hand side of lathe is arranged for turning rolls in the mill chucks.

Improvements in High Capacity Industrial Third Rail Systems

By H. YALE MAGEOCH,
Chief Engineer, Electric Service Manufacturing Co., Philadelphia, Pa.

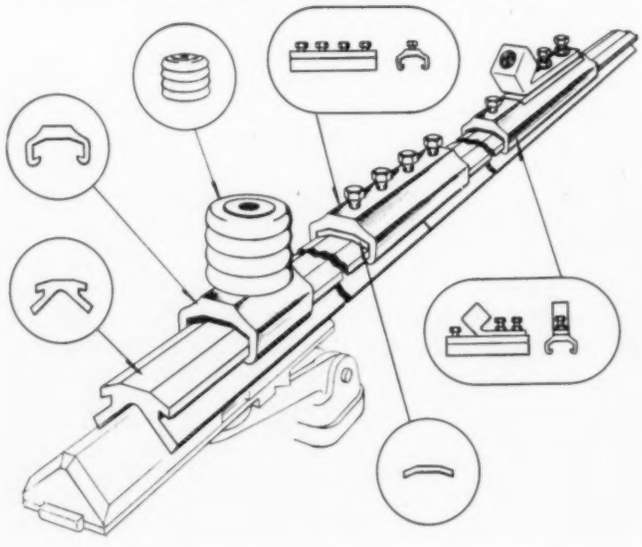
. . . . aluminum offers advantages for conductor systems, and among these are weight savings and better electrical characteristics, a disadvantage is the higher basic material cost . . . . service rubbing apparently also hardens surface of aluminum . . . . distributed contact systems also offer advantages such as easier movement for personnel and equipment and smaller maintenance . . . .

▲ IN the field of high capacity industrial third rail systems, little has been done to change from the old concept of the use of ASCE rails, structural shapes, bus bars or otherwise commercially available material. This material was formed into a system by employing miscellaneous insulators and a wide variety of contact shoes patterned after the idea of numerous designers or users, many of whom were called upon to design the components out of necessity rather than from the accumulated knowledge of a specialist.

With alternating current becoming a popular source of energy for heavy industrial equipment, it became apparent that some study should be given to high capacity systems, embodying engineering principles, where all parts would be designed for use as a system of a co-ordinated nature realizing that many factors should be taken into consideration such as regulation, space required, safety, ease of installation, cost and maintenance problems. Careful study of these factors has made it possible to now procure a system that embodies improved design which may be manufactured on a production basis in package form. Those now engaged in the mechanical construction or use of heavy industrial equipment need not assume the roll of electrical engineers with respect to the problems related to third rail systems. They may procure a third rail system according to a specification and apply it to their equipment with full realization that guaranteed performance is built in and will be secured.

A system of this type, having a capacity of 1000 amperes, has been developed recently employing aluminum for the conductor material. It has been designed for easy assembly at the time of erection with standard components that fit together very much like that of a child's "Erector" set. Reference to Figure 1 shows the basic components of such a system. It employs an inverted "V" contact area with means for connecting the

Figure 1 — Sketch shows components and typical collector for new type aluminum conductor third rail system.



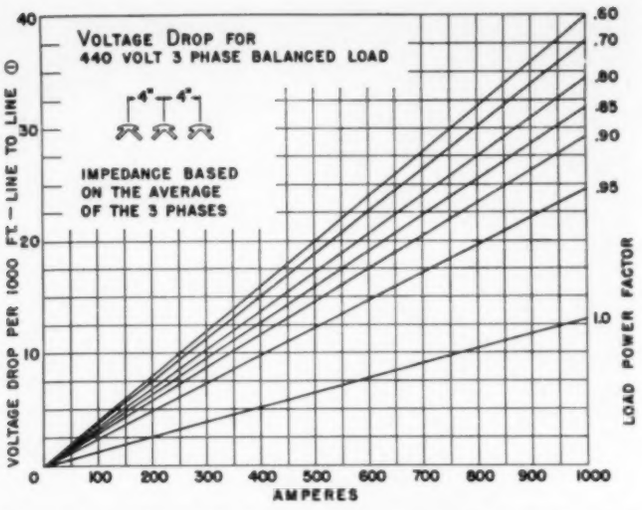


Figure 2 — Voltage drop equals line-to-line voltage at feeder terminals minus line-to-line voltage at collector terminals.

conductor elements in the form of a slidable clamp which holds a spring pressure plate, locked in position by screws, thus assuring continuity of contact between the rails.

The various components such as hangers, insulators and feeder connections are shown in Figure 1. The method of engagement and assembly may easily be seen.

By means of the smaller cross section required when using aluminum as related to steel, a heretofore very popular third rail material, a reduction in space is permitted which is extremely desirable.

The non-magnetic nature of the material assists greatly in reducing the inductive effect. Due to their smaller cross section, the conductors permit locating on relatively short center spacing. This again helps to reduce the overall impedance of the system.

With a system of the design shown, it is possible to design collector shoes purposely constructed for operation with aluminum of the configuration employed. The selection of shoe material has been determined as the result of extensive testing. The most desirable material has been selected compatible with conductor wear and shoe life.

In order to permit calculation of the electrical characteristics of the system, Figure 2 shows the voltage drop per 1000 ft of conductor for a four-in. horizontal, flat spacing as related to current and power factor of the load.

The values employed for the preparation of the chart were determined by results secured on actual test setup. Laboratory meters and a recording oscillograph were used for the purpose of determining the characteristics.

Tests on the shoe were made under actual service conditions by operation on a test runway as shown in Figure 3 and Figure 4. It will be noted from the figures that an outdoor operating system was constructed on the roof of one of the manufacturing plants. The shoes were driven back and forth constantly by a ten hp motor controlled through a suitable relay network. The electrical load, carried by the third rail system, was derived by running one of the three phase legs of the plant's load through the conductor system. Thus, with the equipment under test operating outside in an industrial atmosphere under load comparable to that which would be found in service, it was possible, by making measurements during the test, to determine the characteristics of the system as well as the rate of wear of the shoe and conductor.

In order to study operation under adverse conditions, a water spray method was provided that would constantly keep the system operating in an atmosphere of fog or direct moisture, thus reproducing the worst condition to be anticipated at any time.

It was found that the greatest rate of shoe wear took place under conditions of moisture and with the system operating with reasonable frequency. Therefore, it was necessary to select a shoe material that would

Figure 3 — A test collector runway was built.

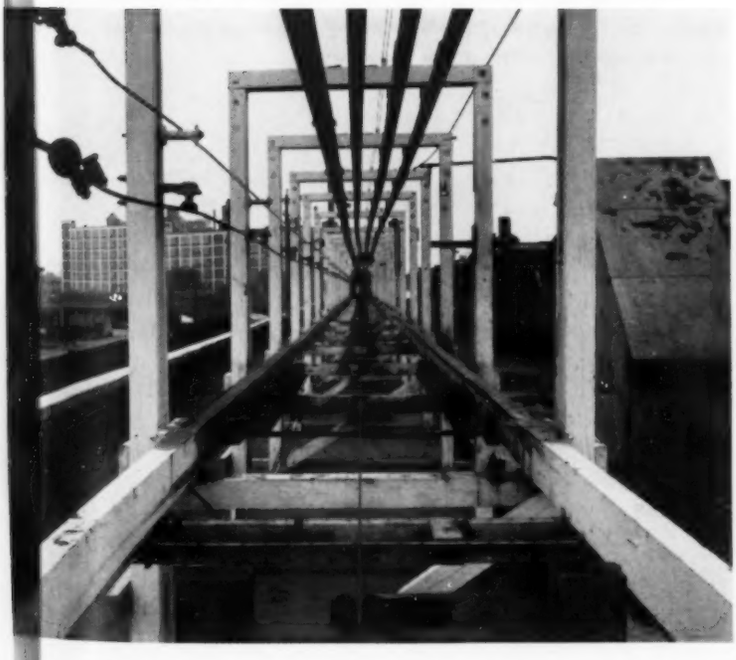
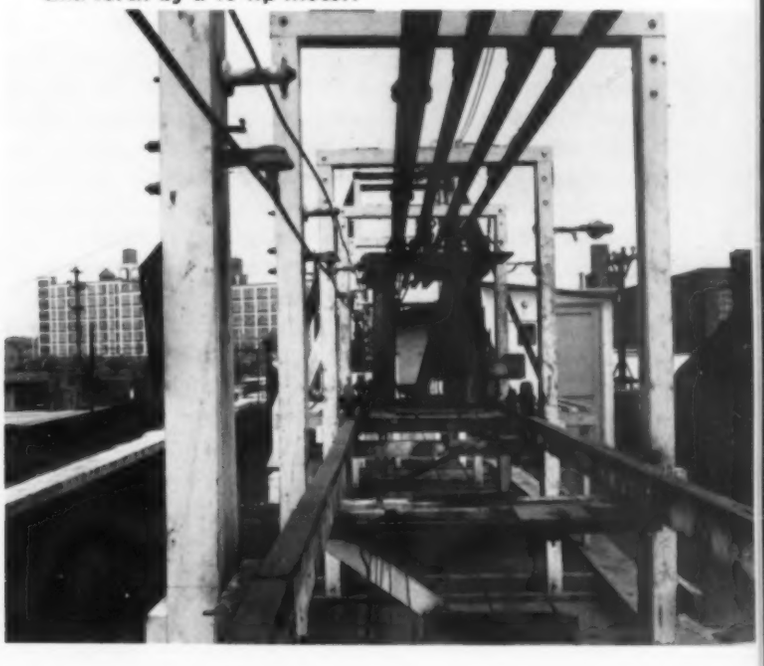


Figure 4 — Shoes are mounted on a trolley and moved back and forth by a 10-hp motor.



withstand this condition and satisfactorily out-perform conventional shoe materials used with steel wire, bus bar or systems now commonly found in service.

The use of aluminum in rubbing engagement with any material might cause concern on the part of an engineer anticipating the use of an aluminum sliding conductor system. Thus, considerable test work and observations were made with respect to this phase of the development of the system.

It was observed that with a new system, operating for the first time, the rate of wear on the conductor appeared to be excessive. However, after a short period of time, it was found that the aluminum seasoned itself and wear was reduced to an extremely low value.

It may be of interest to review a laboratory test that was conducted to determine conditions occurring with various materials sliding on an aluminum surface.

For the purpose of test, a machine was constructed of a type as shown in Figure 5. Notice that this machine consists of two revolving discs of aluminum where the shoe material under test is permitted to slide on the outer periphery of the disc. Various instruments are employed for measuring frictional drag, rate of wear, electrical characteristics of the contact surface at the current transfer point and other factors. The reason for discussing this machine is to show that when tests were first started on a clean aluminum surface, a rapid rate of wear of the aluminum at the point of contact with the shoe material was noted.

At the conclusion of each test and preparatory to the next test, it was our intention to resurface the outer periphery of the aluminum disc by means of a tool which is shown in the left hand side of Figure 5. Our first attempt to resurface the aluminum was done with a high speed tool steel bit. Much to our surprise, we found that we could not resurface the aluminum with this tool. In fact, the aluminum surface immediately removed the edge from the cutting tool and resisted our efforts to resurface it.

We found it necessary to resort to a carboloy tool in order to cut the hard skin formed on the surface of the aluminum. Consequently, we were very much interested in finding out what had happened to the surface to cause this condition.

We can only offer a theory in this respect. This theory revolves around the thought that aluminum and other hard substances, formed by the action of the air and moisture on the aluminum as well as possible alloying of the components of the shoe material with the aluminum, become attached to the aluminum surface either mechanically or by the fact that while carrying current numerous sparks cause the aluminum to vaporize and recondense, thus trapping the hard particles at the aluminum surface. These hard, trapped particles become like a lap. In addition to the hard particles, it is expected that certain elements of the lubricating materials, found in the shoe composition, are also trapped at the surface of the conductor.

From tests made in the laboratory and in the field, this surface condition has little effect on the transfer of current between the shoes and the conductor. Hence, it appears that a relatively soft conductor material develops a surface which becomes resistant to mechanical wear.

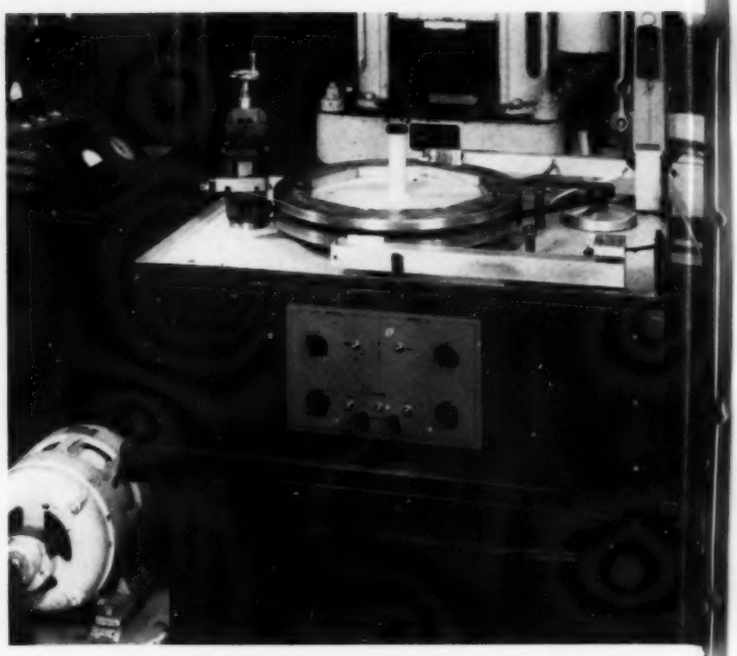
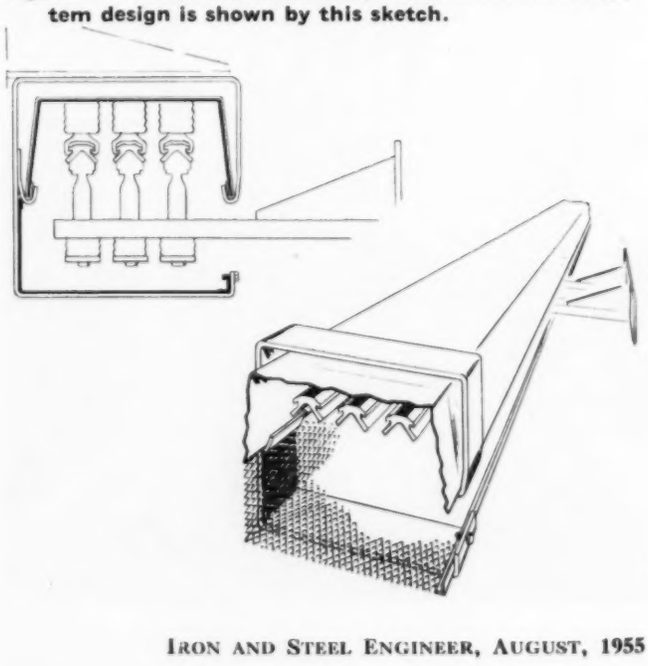


Figure 5 — Tests were made to measure wear and frictional drag between revolving discs of aluminum.

In view of the fact that this condition exists on the surface, it would be anticipated that any shoe having a hard, sharp, projecting nodule, which would cut below the surface, would dangerously score the conductor. Hence, while the surface may become resistant to wear, it is important to employ a shoe of suitable material so that the surface of the conductor will not be damaged by deep gouging action.

In many cases, conditions must be met by industrial third rail systems such as personnel safety or protection against atmospheric interference with the operation of the system. These requirements prompted the design of a standardized enclosure for the system just described retaining the principle of easily assembled parts. The result is an enclosed system of the type shown in Figure 6. Figure 6 shows standard components assembled with the enclosure providing a high

Figure 6 — A 3-phase, 1000-amp, enclosed conductor system design is shown by this sketch.



degree of protection toward safety and guarding against the collection of dirt, snow, ice or other interfering elements.

This system may be easily installed, modified, extended or repaired with the minimum expenditure of manpower.

The electrical characteristics would be similar to those previously described. Practically no engineering time would be required for the layout and installation of a complete system.

Such a system may be provided with insulation for 750 volts, 2300 volts or 4160 volts in which case the overall dimensions would have to be modified to allow for insulation and arc striking distance.

DISTRIBUTED CONTACT SYSTEM

Another form of third rail system has been developed recently which departs materially from the conventional type of system employing stationary rail. This system is based on the use of a series of contacts located at fixed positions along the path of movement of the operating equipment. Hence, along a crane runway there would be found, at fixed positions, contact shoes

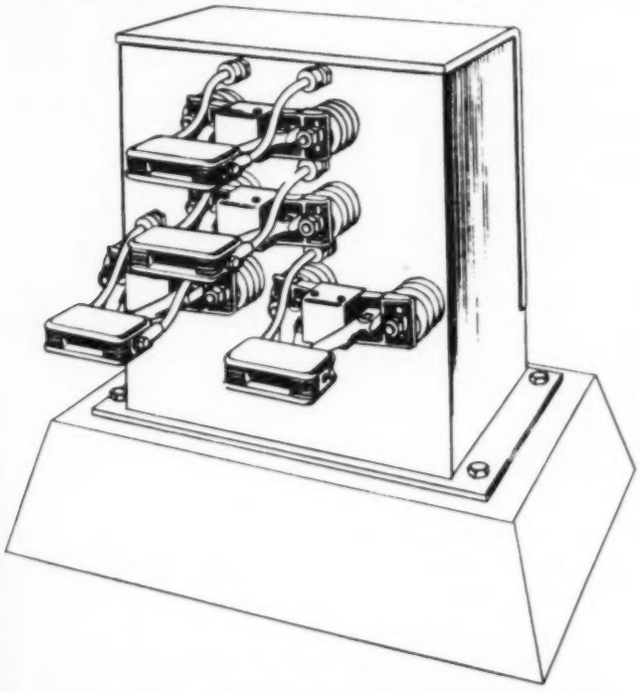


Figure 7 — Typical distributed contact system unit incorporates contact shoes and internally mounted power contactors.

supported by suitable means and arranged so that they will make contact with a length of rail carried on the moving equipment.

Such a system could not be employed in all cases unless certain conditions could be met. For instance, on the base of the moving equipment, it would be necessary that rails of sufficient length could be carried in order to permit the spacing of the posts or shoe supports on reasonably long centers. This would assure low initial cost as well as retaining the advantage afforded by the fact that the posts do not form an obstruction which prevents free movement of workers and equipment over the area serviced by the third rail system.

Certain basic features may now be reviewed. For the purpose of clarification, Figure 7 shows the construction of a post carrying the necessary contact shoes for a three-phase system.

Figure 8 shows a car carrying a rail suitably mounted with the contact shoes shown along the crane runway. The ease with which complicated crossover conditions may be solved is demonstrated by the figure. The safety of the system as well as the elimination of the fence

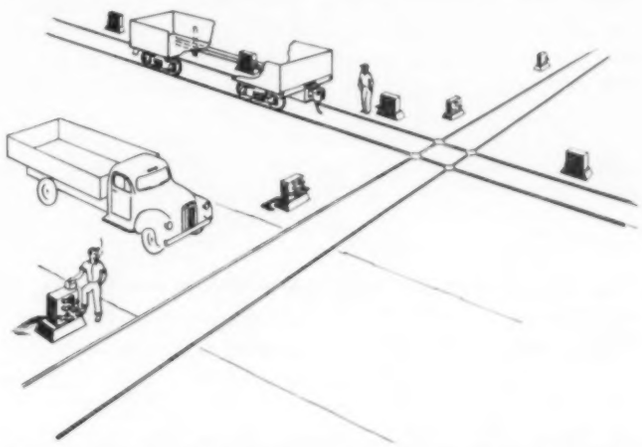


Figure 8 — Distributed contact system gives clear working space, versatility and safety.

effect found with conventional systems at ground level, releases space for free movement of men and materials.

Figure 9 shows schematically how the rail will span the posts making contact with each post, in turn, for current pickup. At no time is the contact between rails and shoes interrupted. A new set of shoes will be contacted before the last set of shoes loses contact with the rail.

The figure shows the wiring diagram of each post, thereby explaining the reason for the extra shoe found on the lower rail. This shoe performs as a control collector for the operation of contactors within the post. Each time the moving rail contacts the control shoe, energy will be applied to the contactor coils.

This closes the circuit between the power shoes and the supply line so that electrical energy will be transferred to the rail. As the rail leaves the trailing contact post, the circuit between the control shoe and the main supply line is broken. Hence, all shoes at the trailing contact post immediately become deenergized and cannot be reenergized by any normal means. Therefore, the shoes remain dead and harmless. Personnel in the area may work with safety even though guard boards or protective structures are not provided.

By studying the circuit briefly, it can be seen that energy applied to the contactor coils will cause the contactors to close and remain closed so long as the circuit is bridged between the control shoe and the lower power shoe.

This action will be repeated as the moving rails advance along the runway. All shoes not in actual contact with the rails will be deenergized since the holding coils on the contacts will have been deprived of their power.

When power is first applied to the system, it is necessary to energize the contactor whose shoes are in contact with the rail by applying voltage to the contactor coil. This involves the use of a simple reset push button circuit which is not shown in the figure.

As may be seen, the method of operation of the contactors is similar to an industrial motor starter whereby a "no-voltage" release is provided. In the event that circuit breaker operation or other interruptions of voltage, the entire system will be immediately disconnected and can only be operated after a maintenance man or other persons in authority are satisfied that all conditions causing failure have been corrected. At that time, operation of the reset button will place the system in permanent electrical contact with the feeder line.

secured for 300 or 500 amperes. The capacity of an installation may be increased, as desired, by placing additional posts in parallel. By example, if a 60-ft spacing is employed in the event that the minimum number of posts would have been installed initially, the current collecting capacity may be increased by installing additional posts so that the end result would be the locating of posts on 30-ft centers. By this means, a minimum of two power shoes would be in contact with the moving rail at all times, thus doubling the current that could be collected by a single set of moving rails.

With respect to mechanical wear on such a system, it can be seen that while less material is used in the overall system, exclusive of feeder conductors, that the wearing elements are now in the form of a large moving contact surface engaging a large number of smaller

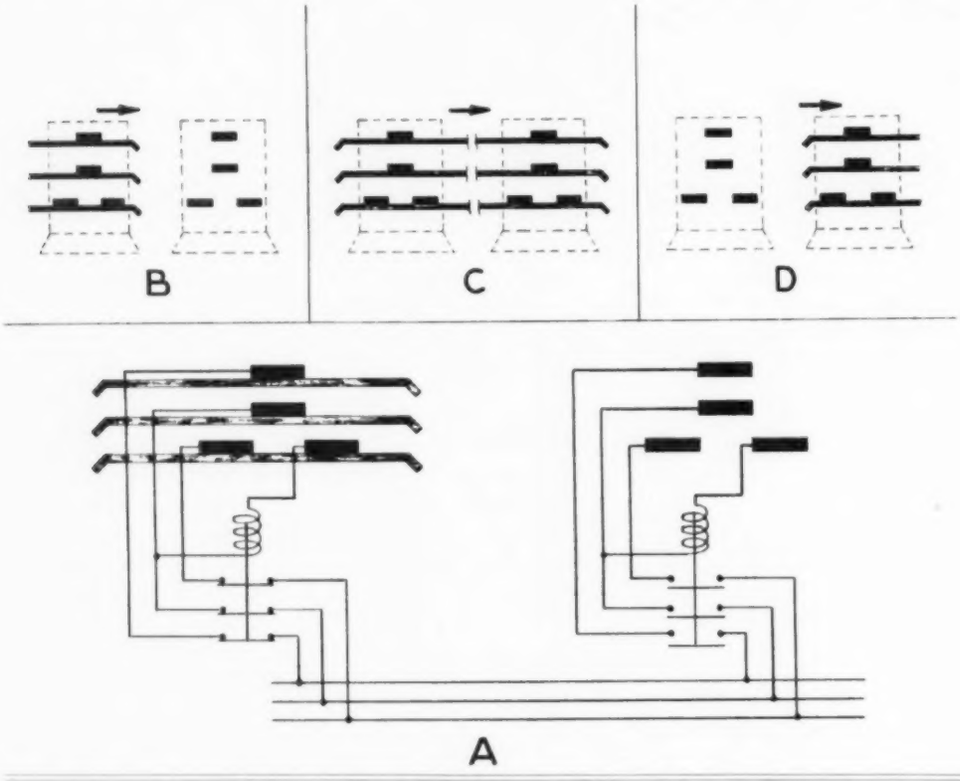


Figure 9—Sketch A shows basic circuit diagram for distributed contact system. Collector shoes on left supply current to moving equipment. Collector shoes on right are de-energized. Sketches B, C and D show progressive movement of conductor rail.

It will be noted that in normal operation of the system, the contactors are never called upon to make or break the circuit. At the time that the reset button is operated it is, of course, necessary for the contactors to make the circuit which at that time would be under no load or a light load.

From the electrical point of view, when using alternating current, it is obvious that the impedance of the system may be held to a low value by employing in the case of a three phase system a three conductor cable. For convenience in determining the impedance of such a system, Figure 10 shows the impedance of a 500-MCM three-phase bonded cable.

A system of this type is extremely easy to install and can be figured by any contractor or electrical department. The posts with shoes and contactors can be obtained already wired and the only requirement is to mount the posts in the required position and to make the electrical connections to the terminals within the posts by following the procedure such as that used for any motor starter. Posts of the type described may be

contact surfaces. Contrasting this with the old system having a small shoe operating on a rail, the shoe is at all times exposed to the effect of wear with the wear being considerably greater than the rate of wear found on a section similar to the moving rail section just described.

To review, some of the advantages that such a system affords, are as follows:

1. Permits free movement of personnel and equipment over the areas serviced by the power supply system.
2. Provides maximum safety without complicated, inefficient guard boards or requirement for elevating the system or carrying it underground.
3. Provides very good regulation in the case of alternating current and equals the regulation of any direct current system.
4. Maintenance can be provided without equipment shutdown.
5. System will operate under adverse weather conditions where rail or wire systems would be inoperative.
6. Systems can be supplied to work in corrosive

atmospheres normally damaging to conventional systems.

7. The system can be designed to operate without servicing where long periods of exposure, under idle conditions, would normally corrode or contaminate conventional systems (this refers particularly to dam installations).

8. Under certain conditions where feeder conductors, required for other use, parallel the operating track, installation costs may be greatly reduced.

9. Installation may be made by any contractor without special knowledge of third rail systems due to the fact that electrical energy to the individual contact shoes may be supplied by power conductors installed in accordance with the Underwriter's code.

10. The system may be employed for remote control of the moving equipment from a stationary point such as that required for special process plants.

11. Due to the fact that less material is used in this system than the conventional system, special metals may be employed for the contact shoes in order to meet unusual operating conditions.

12. Installation is simplified by completely wired unit assemblies.

13. Completely eliminates problem due to expansion and contraction.

DISCUSSION

PRESENTED BY

HARRY H. ANGEL, Electrical Construction and Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

WILLIAM C. BENNETT, Electrical Engineer, Alliance Machine Co., Alliance, Ohio

C. O. FRANKLIN, General Supervisor—Electricity and Engineering, Homestead District Works, United States Steel Corp., Munhall, Pa.

A. J. F. MacQUEEN, Electrical Superintendent, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

H. YALE MAGEOCH, Chief Engineer, Electric Service Manufacturing Co., Philadelphia, Pa.

H. H. Angel: The Bethlehem Steel Co. has two underground aluminum collector systems in shipyards, supplying 240 volts d-c. A system for 480 volts, 3-phase, 60 cycles, a-c is now on order. The length of each system is from about 450 ft to 800 ft. As far as I know, each is performing satisfactorily. Recently a large gantry crane was purchased for one of our fabricating plants, and since the power will be 480 volts, 3-phase, 60 cycles, and the length of travel almost 700 ft, several collector systems were investigated. One of these was the unloader installation of the Canton Co. in Baltimore. This system supplies power for 2300 volts, 3-phase, 480 volts, 60 cycles, d-c control, and adjustable voltage power. The salt atmosphere has a slight adverse effect on the aluminum. In the morning, after an overnight shutdown, the operators are instructed to run the trolley several times over the length of the bridge before handling loads. Mr. Mageoch may wish to comment on this.

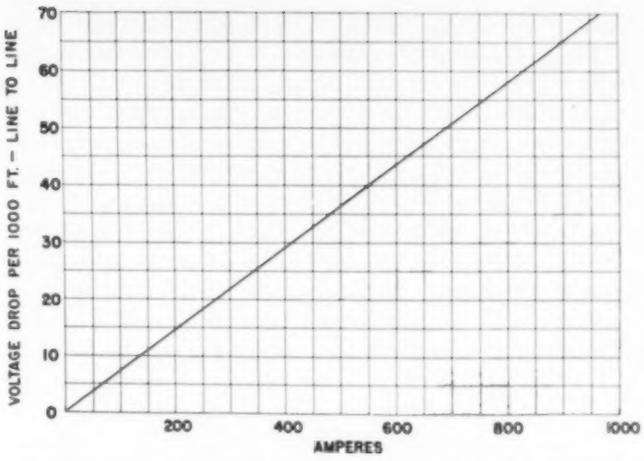


Figure 10 — Curve gives voltage drop at 80 per cent power factor for 440 volt, 3-phase cable composed of 3 conductors, each with 500,000-circular mil cross section, banded together.

The fabricating plant collector system will be fed from a tap in the center. The calculations for voltage drop at the extreme end of the runway, assuming 150 per cent full load starting current for bridge and main hoist simultaneously, show about 6.2 volts without collector shoe contact loss, and about 9 volts using the author's chart, Figure 2. Spacing will be approximately 5½ instead of 4 in.

One of our steel plants now has two aluminum conductor systems on order for handling electric welding in a car shop.

W. C. Bennett: The development of pre-packaged and pre-engineered systems is a valuable contribution to the industry. The aluminum conductor system appears to be one that offers great advantages over conventional steel structural shapes and rails from the standpoint of impedance losses, physical considerations, and economy, and over copper bus because of weight and economy. The shape selected appears to be excellent for good heat dissipation, but does not appear to be adaptable to a wheeled trolley collector. The toughening of the surface of the aluminum is an intriguing development. Is the shoe material carbon? What is the effect of a salt atmosphere on the conductors, and is the toughened surface still conductive in a salt atmosphere? It will be interesting to hear further developments on this.

The distributed contact system offers distinct advantages for many applications. It is noted that post type systems have previously been described by Mr. Mageoch in The Iron & Steel Engineer of November 1950, in his excellent article, "Sliding Contacts for Transfer of Electrical Energy for Industrial Systems." However, this was not a packaged system nor did it have the same safety feature. The voltage rating of the packaged system would be limited by that of the contactors, or 550 volts if NEMA standard contactors are used. Has there been a study of this system on higher voltage application?

What has been the attitude of the various safety groups and state code inspectors regarding the acceptability of the safety feature? The future may bring increased demand for greater safety in the application of

conductor systems—the activities of the state of California being noted in particular. It is a lot of trouble to design a system for each application and obtain approval of it. An approved system that could be simply applied would eliminate this. Packaged systems available for the solution of this problem will be welcomed.

C. O. Franklin: My discussion will be limited to collector systems for steel mill cranes operating at 230 volts, d-c. Many changes and improvements have been made in these systems during the past thirty-five or forty years. From my observations the various stages in the evolution of the modern system were as follows:

1. Trolley wires of hard drawn copper were used for both main runway and cross travel conductors. The collectors consisted of grooved brass wheels made in the home foundry. The cross travel conductors were located between the girders where they were inaccessible for maintenance and subject to damage by the hoisting ropes.
2. The cross travel trolley wires were moved up to the follower footwalk where they were more accessible and less subject to damage.
3. ASCE rails of 12 to 16 lb size were substituted for cross travel trolley wires. Cast iron shoes bearing on the head of the rail were used for collectors. Both rail and collector shoe supports were made of hardwood of about 4 x 4-in. cross section and were boiled in paraffin to make them impervious to moisture.

   The main runway conductors consisted of rails of larger size, depending on the crane load and were supported by hardwood blocks fastened to the runway girders. The main collectors were cut from heavy steel plate and bore on the head of the rail.
4. When 12 and 16-lb rails became unavailable, angles or bars were substituted for cross travel conductors.
5. Porcelain insulator supports replaced the hardwood blocks for main runway conductor rails.
6. Booster cables were connected in parallel with the main conductor rails to minimize voltage drop. The booster cables were fastened to the rails by specially designed clamps spaced about eight or ten ft.
7. The booster cable clamps proved unsatisfactory and welding of the cable to the rail was substituted.
8. The latest development is the system described by Mr. Mageoch and it appears to have all the desirable qualities such as good conductivity, light weight and ease of installation. If the price is within reason, this system should prove very attractive to crane builders and users.

As an example of the light weight of these conductors as compared to steel, I know of an installation where they are being used as cross travel conductors on a new ore bridge now under construction. The original design called for eight steel rails with a total weight of 32,695 lb. The aluminum conductor system described by Mr. Mageoch was substituted. It required ten conductors on account of current capacity limitation, but the total weight was only 6100 lb, a saving of 26,595 lb or 81.5 per cent.

I was also very much interested in the author's description of a collector system employing a series of contacts located at fixed positions along the path of movement of the operating equipment. I know of a similar system, operating on 230 volts d-c, which was in use about 35 years ago in connection with a slab transfer car. This system employed a strong electromagnet on the car which picked up the contactors in the stationary boxes and made electrical contact between the rail sections and the tops of the boxes as long as the rails were over the boxes. This system proved expensive to maintain and was discarded after a relatively short period of operation. However it may be of historic interest as most modern developments evolve from such small beginnings.

A. J. F. MacQueen: There is one question in connection with collectors in which I am particularly interested, and that is the matter of determining collector size. This will apply to any given material. I do not want at this point to get into the relative merits of steel versus aluminum.

In determining collector size, usually we consider current rating, and there is mention of 1000-amp collectors and 500-amp collectors. It seems to me that that does not mean too much, because in any given installation it is pretty tough to determine exactly what the equivalent rms heating value of your actual load is going to be. It is particularly hard to predict it in a new installation and, as a matter of fact, I have never yet heard of a crane collector which was overheated.

The same sort of remarks apply to the matter of voltage drop. It is difficult to determine just what the voltage drop is actually going to be. I have known of very few cases of difficulties through excessive voltage drop. I can recall one or two occasions where there was some trouble. It turned out to be a matter of not enough copper in the feeders to the collector rail, rather than in the collector rail itself.

Thinking along those lines, it would seem that most of the crane collectors in service in the present day are considerably over size insofar as heating or voltage drop is concerned. There are a variety of sizes used in the various plants. Each plant has a sort of standard of its own, and they vary considerably from plant to plant. On comparable service, servicing comparable sized cranes and comparable length of runway, one plant will use a 3 x 3-in. angle, another plant will use a 100-lb rail. If you check the current rating, the voltage drop, you will find that either is over size.

It seems that our experience has shown that there is an advantage in having a heavy conductor. Apparently it is a matter of rigidity which seems to point to the fact that the uniformity of contact has an important bearing on the size, but apparently we seem to be a little at a loss at the present time as to just how rigid the collector should be, and possibly we do not really know why. Maybe we should know a little more about the actual phenomena of current transfer at the point of contact.

I would like to quote an instance of what happened when a collector setup was changed. The original collector system in this particular instance was in an open hearth, serving the cranes on the charging floor. It was an old building, the cranes were old, with sleeve bear-

ings, and open gears. The motors were old. The control was old, being mainly manual control. I think there was only one magnetic panel in the whole group.

The collector originally put up was a 1 x 2-in. steel bar on edge, supported every 10 ft. It was pretty flimsy, but actually the voltage drop with the small conductor cross section was not severe enough to ever give any trouble to the operators. It never became overheated. However, we did have mechanical trouble with it since it was so flimsy it bounced around quite a bit and the shoes dropped off. So we changed it. We installed 85-lb rail on porcelain insulators.

The change took care of our collector troubles all right, but there was an odd fact that turned up. In the year following making the change, as compared with the year previous to making the change, the motor burn-outs—and we had had quite a few with this old type equipment and old motors—were reduced somewhere in the order of 30 to 40 per cent, which seemed quite significant. It seemed to indicate that possibly there is more to this matter of determining collector size than just simply checking the current capacity by ordinary standards and the voltage drop that you might expect, assuming a certain set of conditions.

I would like very much to have Mr. Mageoch amplify this line of thought and possibly help to clarify the situation regarding the determination of correct collector size.

H. Yale Mageoch: The first question was presented by Mr. Angel.

He stated that a slight adverse effect was noted on an aluminum system installed where a salt atmosphere was present.

At the present time, we do not know of any material commonly used that does not develop some form of corrosion; so while we are weighing the effect of corrosion on one type of material, we should also consider the effects of corrosion on other materials that might have been used under the same conditions.

Mr. Angel commented that after shutdown that the contact shoes, carried by the trolleys, were moved over the conductors a number of times before starting the equipment. This is good practice as it mechanically cleans the system.

Where a system stands for a long period of time, the user should anticipate that some maintenance will be required before the system can again be placed in operation.

Another comment was on voltage drop where calculation of voltage drop under 150 per cent overload was found to be 6.2 volts, while data taken from the curve indicated 9 volts. It is possible that the 6.2 volts is the line-to-neutral drop. The curve is plotted for a line-to-line drop. If the 6.2 volt phase drop would be converted to a line-to-line drop, the figures would be in agreement with allowance for the difference in conductor spacing.

Mr. Bennett was good enough to comment on the paper and remarked on the possibility of using a wheel type collector on the aluminum conductor. So far, we have felt we have had enough on our hands to develop a sliding shoe and have not made extensive tests using a wheel on the aluminum conductor. It would mean that we would have to use an inverted type of wheel. All elements of the wheel contacting the conductor would be running at different speeds which would set up a slip or skidding action at the contact surface. From an electrical point of view, the wheel forms a two-point contact which means that with the system standing, it would be difficult to carry an appreciable amount of current.

With respect to the shoe material that is employed, the material is basically copper graphite where the percentage of graphite is extremely low with respect to the percentage of copper. We have better ideas on shoe materials than copper graphite. Unfortunately they would be too expensive to offer at this time.

Numerous tests on the outdoor equipment shown have brought to light large differences in the performance of various types of copper graphite now available and out of possibly 150 tests that we have performed, we have found three materials that we would consider acceptable for use on the aluminum conductor system described.

With respect to the voltage rating of the distributed contact system, it is true that it would be limited by the contactors. At the present time, it would be limited to 440 or 550 volts in order to permit us to employ commercially available contactors. The voltage that could be handled would be controlled by the insulation used to support the shoes and the availability of special high voltage contactors.

Concerning the attitude of various safety groups, we have no cross section of their attitude on this type of system. Comparing its effectiveness with systems that are now accepted, it appears that they would be inclined to give it approval for the reason that once the moving equipment has moved from the shoe which it last contacted, there would be no voltage appearing on the free contact shoe.

At the present time, we know of no sliding contact system so completely protected whereby it would not be possible to contact the conductor in some way. Some systems employ a flexible envelope around the conductor, but in all systems observed so far, the envelope may be entered accidentally so that even with its apparent high degree of safety, the system cannot offer the same degree of safety that can be secured by actually disconnecting the conducting element from the feeder line.

Mr. Franklin's discussion was very interesting. He covered the history of third rail systems from the beginning to the present time. I regret that he did not go a little further and do some predicting for us.

On the cost of the aluminum system that has been on the market for a short period of time, I believe that the installed cost would be found favorable with respect to a steel system of similar capacity or a steel system with a booster having equal capacity. This thought is borne out by information that Mr. Franklin gave whereby 26,595 lb of material were saved. I do not know whether Mr. Franklin meant that the saving was in the conductor or whether it was possible to lighten the structure supporting the system thereby saving material. If it is only the conductor, then additional savings could be secured by lightening the supporting structure holding the conductor system.

Mr. MacQueen has imposed a problem. I think his

question was how to determine the conductor and collector size.

With respect to the rating of the conductor so far, we as manufacturers, have established ratings based on heating and for this purpose have used the Underwriter's code applying to bus bars for establishing these ratings.

Concerning the rms value of the connected load, it would be up to the operator knowing his own conditions to establish the rms value, as this value can only be established by a survey of the operating conditions.

Mr. MacQueen also comments that many of the systems today are much bigger than they need to be. One reason for this situation is that usually the user does not know the diversity factor for his own load and merely sends to the supplier of third rail equipment data on the connected load. With no way of determining the diversity factor, the supplier of the third rail material has to play safe and design the system for the connected load which, therefore, places a large installation on the user's property. If there were some simple way of actually determining the diversity factor with allowance for contemplated expansion, it would be a good idea.

Mr. MacQueen talked about voltage drop.

It would be anticipated that an operator considering the installation of a conductor system would first consider the normal current that the system would be required to carry and then select a conductor and collector that would be within the manufacturer's rating based on heating.

After selecting the conductor and collector, the peak load should be determined at which there should be retained a given voltage on the operating equipment. If the peak load cannot be established, 200 per cent of full load might be assumed for checking purposes.

A regulation or voltage drop calculation should then be made to determine if with the conductors and collector selected there will be sufficient voltage under peak load at the equipment to permit proper operation.

In some cases, the use of oversize conductor material is not decided by the supplier of the third rail equipment but often comes about by the fact that the customer rolls a particular size rail which they would like to use or they have taken the rail from some other installation which results in the use of a rail or a conductor of extra large size.

Another comment by Mr. MacQueen was one which, in my opinion, is outside of the sphere of the third rail supplier and that has to do with the condition whereby when the change was made from bar to 85-lb rail that a motor burnout condition was helped or improved. I can only guess as to what has happened in this case. As I understand the situation, Mr. MacQueen's installation was a d-c installation and he stated that with the bar system which was a little flimsy that the shoes would from time to time leave the rail.

It could be anticipated that with the d-c system, with motor load and inductive load connected in parallel, that each time the circuit would be broken by the shoes leaving the rail that a high inductive surge might be imposed on the system by the inductive load such as magnet coils, brake magnets and so forth. The surge could cause a voltage that would exceed the withstanding voltage of the insulation and under such a condition, motor failures might be promoted.

In a system where the shoes would not leave the rail, there would be no break in the circuit with the result that no inductive surge would appear on the line. One thought to help reduce the possibility of a surge appearing on the line would be to place more shoes in parallel on the conductor so that if one leaves the conductor, the other will still remain in contact. If this procedure would be followed, it could help the situation but I am only surmising, in this case, the reason for the reduction in motor failures.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill," published by the Association of Iron and Steel Engineers. If your copy is not in use please get in touch with us.

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ASSOCIATION OF IRON AND STEEL ENGINEERS

1955 Annual Convention

HOTEL SHERMAN
CHICAGO, ILLINOIS

SEPTEMBER 26, 27, 28 and 29

Program

ASSOCIATION OF IRON AND STEEL ENGINEERS

1955 CONVENTION

HOTEL SHERMAN

CHICAGO, ILLINOIS

September 26, 27, 28 and 29

Monday, September 26

9:00 am — REGISTRATION — Old Chicago Room

9:15 am — BUSINESS MEETING — Louis XVI Room

Conducted by President John H. Vohr

9:30 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: R. J. Beeswy, Electrical Superintendent, Inland Steel Co., East Chicago, Ind.

A. J. F. MacQueen, Electrical Superintendent, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

"Improved Mill Performance Through Modernized Electrical Control," by E. B. Fitzgerald, Assistant Division Manager, Industrial Control Sales, and Eric Pell, Engineering Supervisor, Cutler-Hammer Inc., Milwaukee, Wis.

"Power Requirements and Selection of Electric Equipment for Hot Strip Mills," by R. E. Marrs, Steel Mill Application Engineer, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

"Tonnage Heating by Induction," by R. S. Segsworth, Director of Research, The General Engineering Co., Ltd., Toronto, Canada, and M. C. D. Hobbs, General Superintendent, Western Canada Steel Co., Vancouver, B. C., Canada

9:30 am — OPERATING PRACTICE SESSION — Crystal Room

Chairmen: Robert Sergeson, Chief Metallurgical Engineer, Rotary Electric Steel Co., Detroit, Mich.

F. E. Robinson, Assistant Division Engineer, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio

"Layout and Design of Ingot Mold Foundries," by Glenn W. Merrefield, Foundry Engineer, Giffels and Vallet, Inc., Detroit, Mich.

"The Effect of Finishing Temperature on the Properties of Hot Rolled Steel Plate," by R. H. Frazier, F. W. Boulger, Assistant Chief and Chief, Division of Ferrous Metallurgy, and C. H. Lorig, Technical Director, Physical and Process Metallurgy, Battelle Memorial Institute, Columbus, Ohio

"Hot Extrusion of Carbon Steel Solid Sections," by Joseph K. Seyler, Superintendent, Hazelwood Cold Finishing Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

2:00 pm — COMBUSTION SESSION — Louis XVI Room

Chairmen: F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

F. C. McGough, Superintendent Power and Fuel, Detroit Steel Corp., Portsmouth, Ohio

"Balanced Pressure Coke Oven Gas Distribution," by H. V. Flagg, Combustion Engineer, Armco Steel Corp., Middletown, Ohio

"Local and Interplant Gas Dispatching in Steel Plants," by H. J. Rohm, General Coordinator, Fuel and Power, United States Steel Corp., Pittsburgh, Pa.

"Experiences in Purging Plants and Mains," by Hugh E. Ferguson, Chief Testing Engineer, The Peoples Gas Light and Coke Co., Chicago, Ill.

2:00 pm — ROLLING MILL SESSION — Crystal Room

Chairmen: George A. Henderson, Superintendent Rolling Mill Div., Bethlehem Steel Co., Lackawanna, N. Y.

R. C. Schaefer, Superintendent Hot Strip Mill, Wheeling Steel Corp., Steubenville, Ohio

"The Use of the Modern Assel Mill in the Production of Seamless Steel Tubing," by Charles E. Snee, General Foreman, Assel Mill, Steel and Tube Div., The Timken Roller Bearing Co., Canton, Ohio

"Modernization of the Hot and Cold Continuous Strip Mills, Bethlehem Steel Co. — Lackawanna Plant," by F. S. Eckhardt, Chief Engineer, Lackawanna Plant, Bethlehem Steel Co., Lackawanna, N. Y.

"Rolling of Thin Strip, Part II," by M. D. Stone, Manager Research and Development, United Engineering and Foundry Co., Pittsburgh, Pa.

Tuesday, September 27

9:00 am — ELECTRICAL SESSION — Louis XVI Room

Chairmen: Ray T. Winterringer, Assistant Superintendent, Electrical Dept., Republic Steel Corp., Chicago, Ill.

F. H. Wickline, Electrical Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

"Integrated Electro-Mechanical Press Puller Drive System Improves Extrusion Quality," by R. C. Suttle, Application Engineer, Metals Div., Reliance Electric and Engineering Co., Cleveland, Ohio

"Contributions to Arc Furnace Operations," by L. A. Wynd, Superintendent Electrical Dept., Republic Steel Corp., Chicago, Ill.

"Increasing Capacity of Ladle Cranes," by Eugene Whitaker, Mechanical Engineer, Granite City Steel Co., Granite City, Ill.

"Report on Standardization of Additional AISE Mill Motor Frames," by M. B. Antrim, Chairman, Mill Motor Committee, and Assistant Manager, Maintenance and Construction, Lukens Steel Co., Coatesville, Pa.

9:00 am — MECHANICAL SESSION — Crystal Room

Chairmen: J. B. Whitlock, General Maintenance Engineer — All Plants, Armco Steel Corp., Middletown, Ohio

C. W. Bruce, Chief Engineer, Republic Steel Corp., Chicago, Ill.

"Welded Structures as Applied to Cranes and Mill Equipment," by I. W. Evans, Chief Welding Engineer, Morgan Engineering Co., Alliance, Ohio

"Ideal Maintenance Machine Shop Facilities," by W. J. Pearson, Machine Tool Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Protective Coal Tar Coatings in Steel Plants," by Dr. W. F. Fair, Jr., Coatings Consultant, Tar Products Div., Technical Dept., and H. J. Cibula, Sales Representative, Tar Products Div., Sales Dept., Koppers Co., Inc., Pittsburgh, Pa.

2:00 pm — COMBUSTION SESSION — Crystal Room

Chairmen: F. Bruce Bevelheimer, Power and Fuel Engineer, Steel Div., Rouge Plant, Ford Motor Co., Dearborn, Mich.

George J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.

"Fans For Iron and Steel Mills," by Robert Jorgensen, Assistant Chief Engineer, Buffalo Forge Co., Buffalo, N. Y.

"Developments in Steam Generation for Steel Plants," by F. X. Gilg, Executive Assistant, and Norman W. Young, Assistant Chief Staff Engineer, Boiler Div., The Babcock and Wilcox Co., New York, N. Y.

"Steam-Fuel Ratio Control as Applied to Open Hearth Furnace Operation," by W. H. Kahl, Combustion Engineer, Open Hearths, Inland Steel Co., East Chicago, Ind.

2:00 pm — OPERATING PRACTICE SESSION — Louis XVI Room

Chairmen: George H. Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

George I. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

"Normalizing and Quench-and-Temper Heat Treatment of Steel Products," by James MacGregor, Board Chairman, York-Gillespie Manufacturing Co., Pittsburgh, Pa.

"Increased Steel Production From Desiliconized Hot Metal," by E. C. Wright, Head, Department of Metallurgical Engineering, University of Alabama, University, Ala.

"Oxygen Steel in United States," by C. R. Austin, Manager, Oxygen Steel Div., Kaiser Engineers, Division of Henry J. Kaiser Co., Oakland, Calif.

6:00 pm — OLD TIMERS DINNER — Louis XVI Room

Wednesday, September 28

9:00 am — BLAST FURNACE SESSION — Louis XVI Room

Chairmen: James A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

C. G. Hogberg, Assistant to Vice President, Michigan Limestone Div., United States Steel Corp., Detroit, Mich.

"Recent Developments in Sintering and Pelletizing," by Edwin N. Hower, Manager, and John A. Anthes, Process Engineer, Industrial Dept., Dravo Corp., Pittsburgh, Pa.

"The Installation Of, and Split Wind Blowing With, Topping Turbo Blowers for Blast Furnaces," by E. O. Austermiller, Chief Engineer, and W. A. Smith, Superintendent, Power and Fuel Dept., National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

"Underhearth Cooling of the Bottom of Blast Furnaces: Temperature Distribution and Heat Extraction," by Victor Paschkis, Technical Director, and Taghi Mirsepassi, Research Assistant, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

9:00 am — LUBRICATION SESSION — Crystal Room

Chairmen: D. N. Evans, Assistant Superintendent, Field Forces Dept., Inland Steel Co., East Chicago, Ind.

E. T. W. Bailey, Chief Combustion Engineer, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

"Factors in Solvent Selection and Control of Hazards in the Steel Industry," by John B. Moore, Technical Director, John B. Moore Corp., Nutley, N. J.

"Additives in Steel Mill Lubricants," by M. S. Clark, Chemist, Research and Technical Dept., The Texas Co., New York, N. Y.

"Selection of a Lubricant for Cold Drawing,"
Part I **"Coarse Steel Wire,"** by Bruce W. Siemon, Standard Industrial Compounds Co., Chicago, Ill.

Part II **"Fine Steel Wire,"** by W. B. Bauzenberger, Sales Manager, Apex Alkali Products Co., Philadelphia, Pa.

2:00 pm — COMBUSTION SESSION — Louis XVI Room

Chairmen: G. H. Krapf, Division Superintendent of Utilities, South Works, United States Steel Corp., Chicago, Ill.

R. A. Lambert, Superintendent Steam and Combustion, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"The Continuous Annealing of Tin Plate Strip," by Horace Drever, President, Drever Co., Bethayres, Pa.

"Heating Heavy Sections — How Fast?," by Quentin Bloom, Project Engineer, Selas Corporation of America, Philadelphia, Pa.

"Electric Open Hearth Combustion Control at Algoma," by A. K. Bayles, Chemical Engineer, and D. H. Stanton, Fuel Engineer, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

2:00 PM — OPERATING PRACTICE SESSION — Crystal Room

Chairmen: Robert W. Holman, Assistant Vice President, Research and Technology Div., United States Steel Corp., Pittsburgh, Pa.

M. D. Ayers, Chief Engineer, Wheeling Steel Corp., Wheeling, W. Va.

"Electrostatic Application of Materials in the Steel Industry," by Dr. Emery P. Miller, Director of Research and Development, Ransburg Electro-Coating Corp., Indianapolis, Ind.

"The Practical Approach to Coil Splicing," by R. E. Morton, Vice President and General Manager, Morton Manufacturing Co., Muskegon Heights, Mich.

"Developments in Scalebreaking and Continuous Pickling Lines," by J. I. Greenberger, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

7:00 pm — FORMAL DINNER — Ball Room

10:00 pm — DANCE — Ball Room

Thursday, September 29

9:00 am — LUBRICATION SESSION — Crystal Room

Chairmen: D. C. Whitehead, General Lubrication Engineer, Crucible Steel Company of America, Pittsburgh, Pa.

Charles T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

"Lubrication—Systems and Applications at Fairless Works," by W. E. Rigot, Lubrication Engineer, United States Steel Corp., Fairless Hills, Pa.

"A Practical Approach to a Fuel and Lubrication Problem," by C. R. Burton, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Div., United States Steel Corp., Hibbing, Minn.

"Oil Mist Lubrication and Some of Its Applications in the Steel Industry," by T. M. Murphy, Manager Industrial Sales, Alemite Div., Stewart-Warner Corp., Chicago, Ill.

9:00 am — ELECTRICAL SESSION — Louis XVI Room

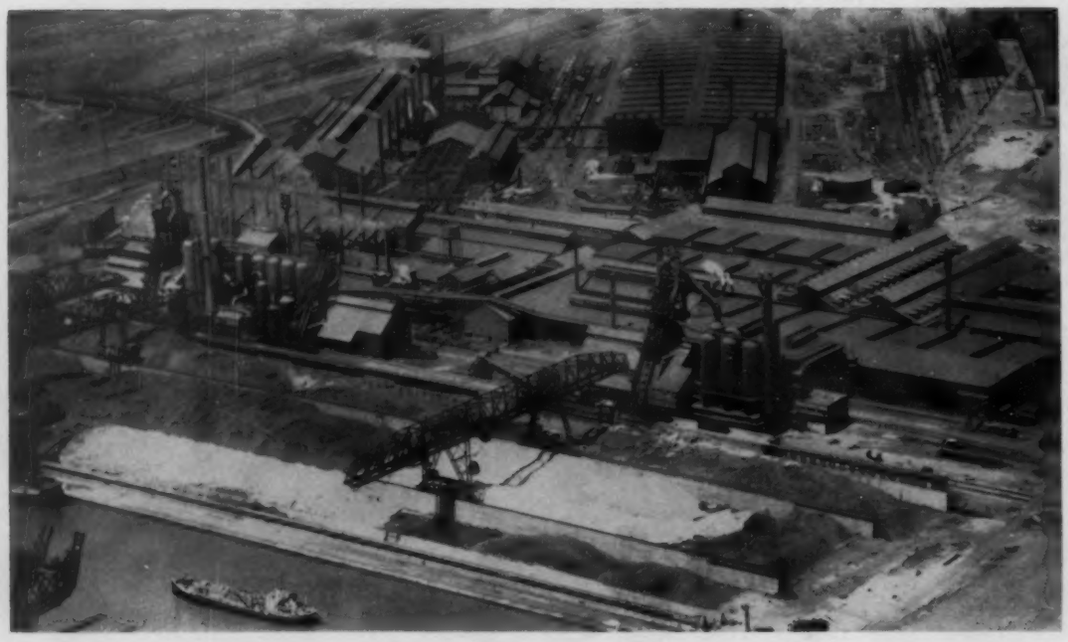
Chairmen: D. C. McCrady, Superintendent Electrical Dept., The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

Richard G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Rectifier Equipment to Supply D-C Power in Steel Mills," by C. S. Hague, Manager, Power Conversion Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Modernization of an Industrial Plant Power Distribution System," by A. C. Stoever, Superintendent of Utilities, Granite City Steel Co., Granite City, Ill.

"Distribution of Power in a Modern Cold Mill," by E. A. Young, Superintendent of Maintenance, Sheet and Tin Mills, Indiana Harbor Works, Youngstown Sheet and Tube Co., East Chicago, Ind., Frank Nolan, Switchgear Engineer, and A. D. Millikin, Rectifier Engineer, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.



1:00 pm — INSPECTION TRIP TO INDIANA HARBOR WORKS, YOUNGSTOWN SHEET AND TUBE CO., EAST CHICAGO, IND.

Buses for the inspection trip will leave from the Hotel Sherman. The trip will cover the many additional facilities installed since the war, and includes new open hearths, hot mills, tube mills, strip mills and finishing facilities. Trip is restricted to citizens of the United States and Canada. No ladies are permitted.

Ladies Program

MONDAY, September 26

9:00 am — LADIES REGISTRATION — Parlor L, Hotel Sherman
3:00 pm — Welcome Party — Wedgewood Room, Marshall Field and Co.

TUESDAY, September 27

11:30 am — Ladies meet in Parlor L
12:00 Noon — Buses will leave La Salle Street entrance of Hotel Sherman for South Shore Country Club
1:00 pm — Luncheon South Shore Country Club

WEDNESDAY, September 28

7:00 pm — Formal Dinner — Ball Room
10:00 pm — Dance — Ball Room

Honorary Chairwoman — Mrs. John H. Vohr *General Chairwoman* — Mrs. R. O. Herbig
Vice Chairwoman — Mrs. Ray T. Winterringer

To partially cover costs, a flat registration charge of $5.00 will be made which will cover all ladies' activities except the formal dinner on Wednesday evening. This must be paid on registering, when tickets will be issued for these events.

New Power, Steam and Blowing Installations at the Ohio Steel Works

By J. P. KATZENMEYER
Project Engineer
United States Steel Corp.
Youngstown, Ohio

. . . . revision of the power, steam and blowing facilities at the Ohio works was accomplished through a well engineered plan which replaced the obsolete and inadequate facilities with modern equipment . . . . careful engineering resulted in a maximum use of existing facilities . . . .

▲ THE Youngstown district, which includes both the Ohio Steel works and McDonald mills, is part of the central operations of the United States Steel Corp. The Ohio Steel works supplies semi-finished steel in the form of slabs, billets, and blooms, to the McDonald mills, located about six miles away, for finishing into bar and strip products.

The Ohio Steel works now consists of six blast furnaces, with an annual rated capacity of 2,003,700 net tons, fifteen open hearth furnaces, with an annual rated capacity of 2,159,000 tons, and two bessemer converters, with an annual rated capacity of 784,000 tons. Open hearth and bessemer steel are rolled into slabs, billets, and blooms by a 40-in., 2-high reversing bloom-

TABLE I

Power Balance

	1945 At close of war		1950 After frequency changers and steam line were added		1953 After new generator was added	
	Average	Maximum	Average	Maximum	Average	Maximum
Power available						
Condensing turbo-generators	14,000	28,000	16,000	30,000	17,000	31,000
Gas power engines	8,000	10,000	4,000	6,000	.....	.....
Purchased power						
Motor-generator sets 60/24 cycle	.....	.....	3,600	4,500	0	0
60-Cycle direct	6,400	7,000	6,400	7,000	6,400	7,000
Topping turbo-generator	.....	.....	.....	.....	14,000	15,000
Total power available	28,400	45,000	30,000	47,500	37,400	53,000
Power Required						
25-Cycle system						
No. 7 to 17 mills, McDonald	12,800	18,500	12,800	18,500	16,200	20,000
No. 18 — 43-in. strip mill, McDonald	10,000	20,000	10,000	20,000	10,000	20,000
Ohio Steel works	4,800	6,000	1,200	1,500	4,800	6,000
60-Cycle system						
60/24 cycle motor-generator sets	.....	.....	3,600	4,500	0	0
60-cycle direct	6,400	7,000	6,400	7,000	6,400	7,000
Total power required	34,000	51,500	34,000	51,500	37,400	53,000

NOTE: Average loads are based on Monday through Friday operations.
Maximum loads are based on peak demands of one hour duration.
Quantities are expressed in kwhr.

TABLE II

Steam Balance

	1945 At close of war		1947 Blower transferred from Edgar Thomson works		1951 Two new pulverizers at No. 9 boiler house and two new turbo-blowers		1953 Two new boilers, new topping turbo-generator and one new turbo-blower	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Steam Generation								
950-psi, 900-F system								
No. 10 boiler house							500,000	550,000
280-psi, 600-F system								
No. 9 boiler house	600,000	800,000	600,000	800,000	700,000	900,000	650,000	850,000
150-psi, 400-F system								
No. 8 boiler house	300,000	350,000	300,000	350,000	300,000	350,000		
Open hearth waste heat boilers	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Total 150-psi steam	500,000	550,000	500,000	550,000	500,000	550,000	200,000	200,000
Steam Requirements								
950-psi, 900-F system								
Topping turbo-generator							500,000	550,000
280-psi, 600-F system								
Condensing turbo-generators	200,000	375,000	200,000	375,000	200,000	375,000	200,000	375,000
Turbo-blowers			80,000	80,000	220,000	220,000	290,000	290,000
Auxiliaries and misc	125,000	150,000	125,000	150,000	125,000	150,000	200,000	225,000
Total 280-psi steam used	325,000	525,000	405,000	605,000	545,000	745,000	690,000	890,000
150-psi, 400-F system								
Blowing engines	350,000	350,000	300,000	300,000	300,000	300,000	200,000	200,000
Steel plant	400,000	450,000	400,000	450,000	400,000	450,000	400,000	450,000
Blast furnace	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Auxiliaries and misc	40,000	40,000	35,000	35,000	25,000	25,000	10,000	10,000
Total 150-psi steam used	840,000	890,000	785,000	835,000	775,000	825,000	660,000	710,000
Steam System Deficits and Excesses								
280-psi, 600-F system								
From 280-psi generation	+275,000	+275,000	+195,000	+195,000	+155,000	+155,000	— 40,000	— 40,000
From 950-psi spillover							+500,000	+550,000
Total	+275,000	+275,000	+195,000	+195,000	+155,000	+155,000	+460,000	+510,000
150-psi, 400-F system								
From 150-psi generation	—340,000	—340,000	—285,000	—285,000	—275,000	—275,000	—460,000	—510,000
From 280-psi spillover	+275,000	+275,000	+195,000	+195,000	+155,000	+155,000	+460,000	+510,000
Total	— 65,000	— 65,000	— 90,000	— 90,000	—120,000	—120,000	0	0

NOTE: Average loads are based on Monday through Friday operations.
Maximum loads are based on peak demands of one hour duration.
Quantities are expressed in lb per hr.

ing mill, and a 43-23-15-in., 3-high reversing blooming and billet mill.

The McDonald mills, which produces a variety of hoop, bar, shape and strip products, now include a 43-in. hot strip mill (No. 8 mill), ten finishing mills (No. 7 to 17 mill group), a bridge floor fabricating shop and a hoop shop.

THE PROBLEM

At the close of World War II, Ohio Steel works found itself with power, steam and blowing facilities that were inadequate to meet the growing demands imposed upon them. It was therefore necessary to improve them to increase and sustain iron and steel production and to augment the rolling mill output, all in accord with policies to support our defense effort and to sustain our civilian economy.

Blowing Facilities—Blast furnace blowing facilities consisted of seven vertical, cross-compound condensing steam engine blowers and four blast furnace gas blowing engines. Of the total complement of blowing engines, nine units were normally available for sustained service, with the resulting shortage of wind causing loss of iron production.

Major steam engine rebuilding and replacement would not improve the availability or efficiency of these units. Therefore, new blowing capacity was essential to increase and sustain iron production.

Power Facilities—Electric power to maintain operations in the Youngstown district was provided by seven twin-tandem gas engine driven 25-cycle generators, two 15-000-kw condensing 25-cycle turbo-generators, and 60-cycle purchased power which amounted to less than 15 per cent of the total power used. The approximate district electric power balance was as shown in Table I.

The total power supply was inadequate to support increasing iron and steel production. In view of the fact that full utilization of all district power generating facilities was necessary in order to sustain steel production schedules, it was apparent that additional generating capacity was required.

Steam Facilities—Steam generating capacity was in-

TABLE III

Blast Furnace Gas Balance

	Before new boilers	After new boilers	Before new boilers	After new boilers	Before new boilers	After new boilers
Blast Furnace Gas Production						
Number of furnaces operating	4		5		6	
Net tons of iron produced per day	4,240		5,200		6,000	
Blast furnace gas produced (cfm)	359,000		441,000		508,300	
Blast Furnace Gas Consumed (cfm)						
Top loss and unaccounted for, (5 per cent)	18,000	18,000	22,100	22,100	25,400	25,400
Stoves (24 per cent)	86,200	86,200	106,000	106,000	122,000	122,000
Soaking pits	2,100	2,100	2,100	2,100	2,100	2,100
No. 9 boiler house	192,400	96,200	192,400	144,300	192,400	192,400
No. 10 boiler house	.....	142,400	.....	142,400	.....	142,400
Gas bleeders	60,300	14,100	118,400	24,100	166,400	24,000
Total (cfm)	359,000	359,000	441,000	441,000	508,300	508,300

NOTE: Blast furnace gas production calculated on the basis of 122,000 cu ft of gas per net ton of iron produced, and 90 Btu per cu ft.

sufficient to meet sustained peak requirements, therefore, at times of high steam load it was necessary to temporarily curtail certain operating units. The situation was further aggravated by the fact that excessive pressure drop in the 1100-ft steam line to the turbo-generators resulted in increased water rates on the turbines and consequently higher steam consumption during the most critical period. As the only relief of the inadequate blowing situation could come from the installation of turbo-blowers, the existing critical steam condition would therefore be amplified.

The steam generating facilities at the Ohio Steel works consisted of No. 9 boiler house, No. 8 boiler house, and 15 open hearth waste heat boilers. No. 9 boiler house contains four water-tube boilers equipped for combination blast furnace gas and coal firing and produced all of the plant 280-psi steam as well as part of the 150-psi steam requirements. No. 8 boiler house contained six coal-fired water-tube boilers and generated 150-psi steam in parallel with 15 open hearth waste heat boilers. The total steam generating capacity was inadequate and did not permit outage time for maintenance. The approximate Ohio Steel works steam balance was as shown in Table II.

In addition, excessive coal firing was required to generate the maximum amount of steam which resulted in excessive fuel costs in view of the availability of adequate amounts of blast furnace gas for this purpose. The approximate Ohio Steel works blast furnace gas balance was as shown in Table III.

Electrical Systems—The control, switchgear and excitation systems for the existing turbo-generators were of inadequate capacity to interrupt the maximum fault currents occasioned by system growth.

TEMPORARY SOLUTIONS

Several measures had been utilized in an attempt to avoid loss of production.

An available 70,000-cfm turbo-blower complete with surface condenser was dismantled and transferred to the Ohio Steel works from the U. S. Steel Corp.'s Edgar Thomson works. The steam balance effect is shown in Table II.

Two 2500-kw, 2300-v, 60-cycle/2300-v, 24-cycle motor-generator sets, along with necessary switchgear, were dismantled and transferred to the Ohio Steel works from the U. S. Steel Corp.'s South works to alleviate the Youngstown district critical power generating situation. To utilize 60-cycle power in a 25-cycle system, the plant lighting system, then 2300-volt, 25-cycle, was connected to 60-cycle purchased power, necessary transformers were purchased, and numerous bus changes were made. In addition, feeder reconnections were made to isolate a portion of the 25-cycle system in order to utilize the 24-cycle power supply provided by the motor generator sets. The district power balance was effected as shown in Table I.

A new 14-in. steam line was installed, parallel to an existing 20-in. line, from No. 9 boiler house to the a-c power house to reduce pressure loss and thus increase the steam pressure at the two condensing turbo-generators when they are carrying heavy loads. This resulted in lower steam consumption for kw produced and enabled the generators to carry higher peak loads.

In addition to the aforementioned, there were several other minor changes made, all aimed at avoiding loss of production.

FINAL SOLUTION

Since gas turbines had not been fully developed for blast furnace blower drives, the only solution to the blowing problem was to install steam turbo-blowers. However, this decision presented an additional problem, namely water for the condensers and steam to operate the turbine drives. The available river water is high in suspended solids and its temperature approaches 100 F at times. Due to this, the condensers on the existing turbo-generators have to be cleaned every two weeks and the vacuum is low between cleaning periods causing higher steam rates than necessary. In view of this experience, cooling towers seemed fully justified. In fact, a complete study showed that the cooling towers, including long supply and return lines due to their necessary remote location, were preferable to installing a complete new pump house including a river intake when consideration was given to the fact that smaller size condensers could be used and blast

furnace production loss due to condenser cleaning outages could be eliminated. Additional steam was attained, as shown in Table II, by installing two coal pulverizers in No. 9 boiler house, thus permitting simultaneous combination blast furnace gas and pulverized coal firing on all four boilers and increasing the steam output of the house enough to operate two new turbo-blowers. The installation of two turbo-blowers was planned and executed so that a third blower could be installed and put into operation with little loss of production. This third blower was installed two years later, along with additional cooling towers.

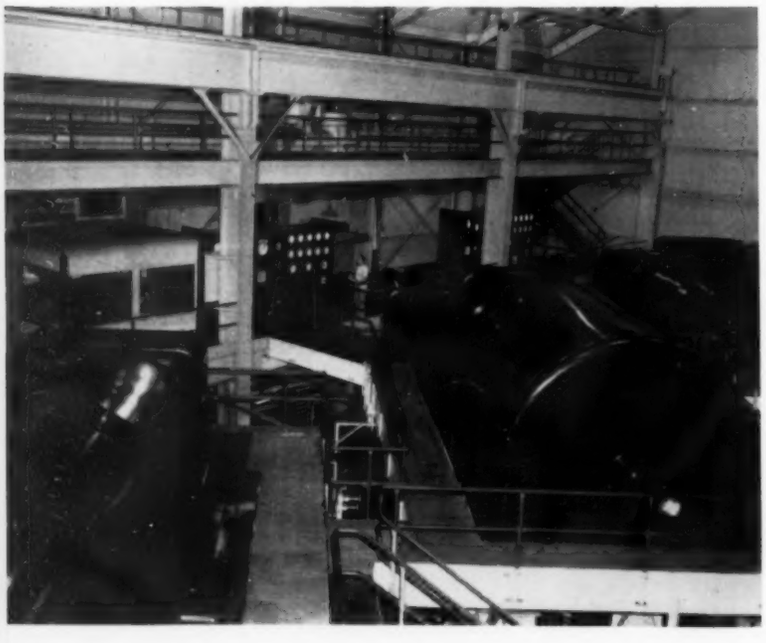
Complete new switchgear for all generators and distribution circuits was the only solution to insure uninterrupted electric power for the Youngstown district.

The power and steam shortage presented several possible solutions and careful consideration was given to their advantages and disadvantages. Of these possible solutions, the only one that would completely satisfy our needs was to install two high pressure, blast-furnace, gas-fired boilers to supply steam to a non-condensing turbo-generator that would exhaust into the plant 280-psi steam system. By installing a 280-psi to 150-psi pressure reducing station, No. 8 boiler house could be abandoned. A 25-cycle generator was chosen to eliminate the necessity of also installing a motor-generator and suffering the kw losses occasioned by converting 60-cycle to 25-cycle, as the probability of materially increasing our 60-cycle load in the near future was remote. The effect on district power, steam and blast furnace gas balances was as shown in Tables I, II, and III.

EQUIPMENT INSTALLED

Turbo-Blowers — Three identical turbo-blowers of the multi-stage centrifugal type were installed, two in 1951 and one in 1953. Each blower has a rated capacity of 90,000 cfm of standard air at 30 psi and is driven, through a flexible coupling, by an 11,300-hp condensing steam turbine with steam at 280 psi and 700 F. The blowers are controlled by a hydraulically operated constant volume control.

Figure 1 — Three 9000-cfm, 30-psi turbo-blowers were installed at a 45 degree angle.



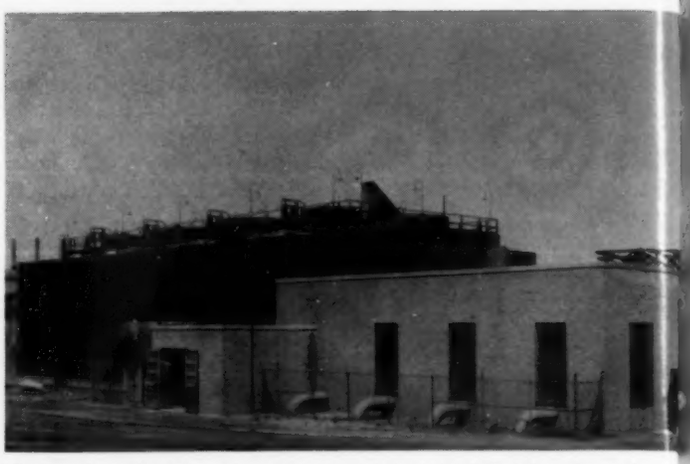


Figure 2 — Cooling tower is constructed of California red wood.

In the past, blowers often proved too small in capacity to meet peak requirements in the range of blast furnace production throughout relining and rebuilding cycles. The new blowers were sized for maximum requirements of the larger furnaces. It was anticipated that use of the blowers on smaller furnaces might cause the blowers to operate at their pumping point so an anti-pumping device was installed. By means of a predetermined setting of minimum volume and pressure which relieves a portion of the wind to atmosphere, the anti-pumping device keeps the turbo-blowers operating above their pumping point.

After examination of the air rotor on the transferred blower and consideration of the economics of the cost of air cleaners versus the cost of an air rotor repair, air cleaners on the blower inlets at Ohio Steel works were not considered necessary. The blowers are of all welded construction.

Figure 1 shows a general view of the new turbo-blowers. Note that they were installed on a 45 degree angle due to limited space at the most desirable location that was within close proximity of the blast furnaces. This arrangement also minimizes the width of the building and provides for maximum accessability.

Each blower is equipped with one surface type condenser of the two-pass design with 10,000 sq ft of surface. One twin element steam jet air ejector of the two-stage type equipped with a surface type intercondenser and aftercondenser, and two (one motor driven and one turbine driven) horizontally split opposed impeller, centrifugal type condensate pumps were installed with each condenser along with other necessary accessories.

Cooling Tower—A cooling tower, consisting of eight cross flow fan cells backed up in a twin flow arrangement, was installed (six cells in 1951 and two cells in 1953) to supply water for the three new turbo-blower condensers. Each cell has a capacity to cool 5000 gpm from 100 to 85 F with a wet bulb temperature of 76 F.

The tower, as shown in Figure 2, is constructed entirely of California heart redwood with bolts, nuts, nails, and timber connectors made of galvanized steel.

Each cell is equipped with an adjustable stainless steel bladed induced draft fan with half of the fans being driven by 60-cycle motors and half by 25-cycle motors as a protective measure against power failures. Design is such that any one cell can be taken out of service without affecting the operation of the remaining cells.

Figure 3 shows a cross section of one of the boilers. It is a vertical two-drum type with water-cooled walls and a water-cooled furnace bottom. The steam drum internals extend the entire length of the drum and consist of a 4-in. feed pipe, a 1-in. chemical feed pipe and a 1-in. continuous blowdown pipe with 30 horizontal

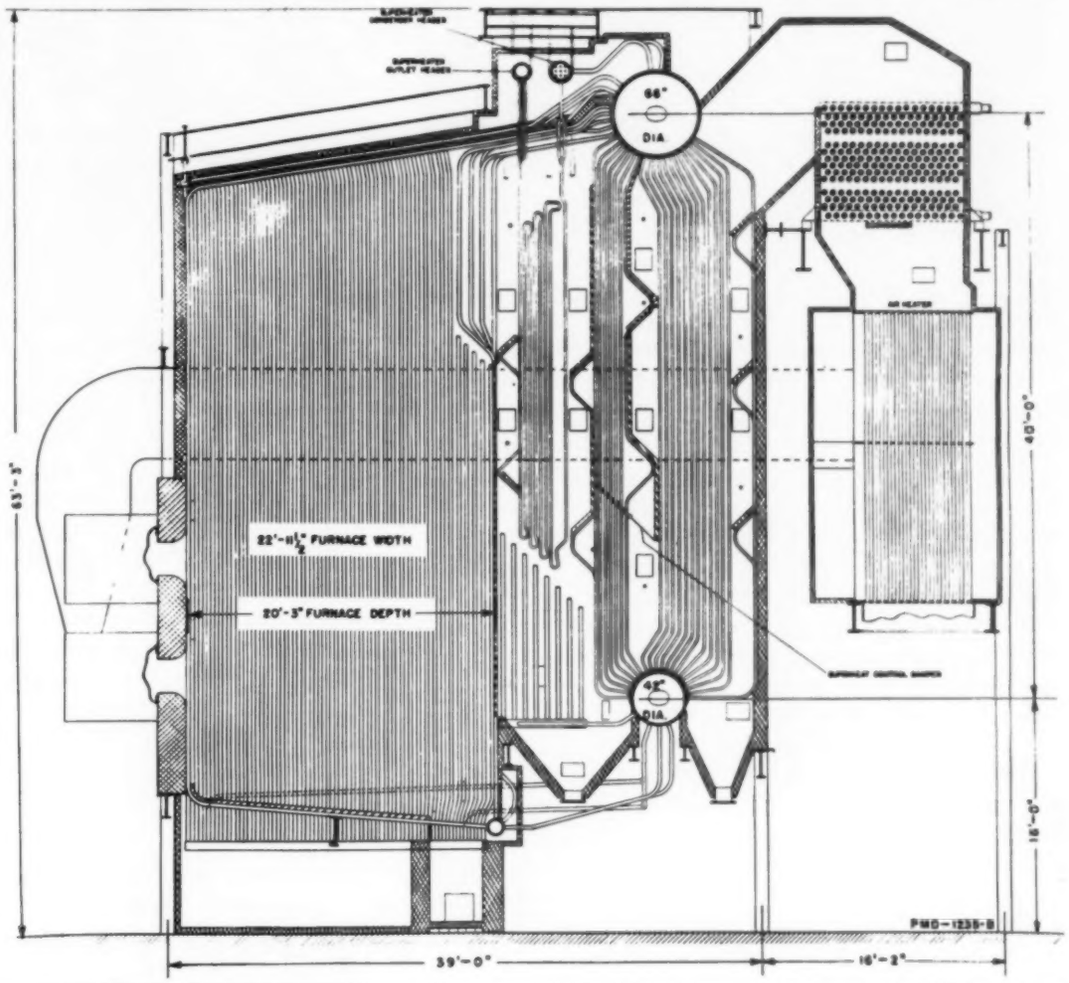


Figure 3 — Boilers are of the vertical two-drum type with water-cooled walls and water-cooled furnace bottoms.

As the only available space for installation of the cooling tower was removed from the turbo-blowers, it was necessary to install two 54-in. concrete supply and return lines, approximately 1300 ft long running from the tower to the blowers. Four horizontal split case pumps (one a spare), having a capacity of 14,000 gpm each with 90-ft total dynamic head, pump the water from the cooling tower basin through the turbo-blower condensers and back to the top of the cooling tower.

These pumps are motor driven by either 25-cycle or 60-cycle current. Make up for the system is added automatically when needed in the basin. The cooling water is treated for slime, scale and algae. As a result, condenser cleaning has not been necessary since the original operation of the turbo-blowers about three and a half years ago. Additional steam and electric power capacity was obtained as follows.

Steam Generating Units—Two new identical 950,-psi, 900-F blast furnace gas fired boilers, with a rated capacity of 250,000 lb per hr each, were put into operation in July and August, 1953, to supply steam at 900-psi, 900-F to the throttle of a new topping turbo-generator, designed to exhaust into the 280-psi, 600-F steam system.

separators, which separate the steam and water entering the drum from the boiler and water wall tubes. The water is discharged down below the water level, and the steam flows to the top of the drum through 13 chevron type purifiers and out to the superheater inlet header.

The superheater is a vertical single pass type consisting of four loops with provision for a fifth loop. It is suspended from the inlet and outlet headers located above the furnace roof, and it lies in the first pass of the boiler. A manually operated damper is provided for bypassing some of the furnace gases around the superheater. This damper is to be left open when burning 100 per cent blast furnace gas and closed in the future for other fuels.

The soot blowing system is an air operated automatic sequential system, using saturated steam from the steam drum reduced to 600 psi. One retractable and eight rotary units are provided on each side for the boiler gas passes. Six rotary units are provided for the economizer which is a horizontal continuous loop tubular type with tubes connecting to inlet and outlet headers, and is of the counterflow design. No soot blowers are installed for the air heater, which is of the vertical tubular type and expected to be self cleaning, with the

Figure 4 — Boiler controls are of the air-operated type.

gases passing down through the tubes, and the air flowing in two passes horizontally across the heater.

Each boiler is equipped with one turbine driven forced draft fan and one turbine driven induced draft fan. Three turbine driven horizontal barrel type boiler feed pumps were installed with one being used as a spare. All auxiliaries operate from the plant 280-psi steam system which saved equipment and piping cost while utilizing a more dependable steam source and enabling start up from other plant boilers. Steam auxiliaries were used exclusively due to their reliability and the need for 5-psi exhaust heating steam.

An existing building, that previously housed four gas engine driven blowers was available at the site picked for the new boilers. Although excavation was necessary in order to fit the boilers in this building, considerable money was saved in dismantling and new building costs, and earlier operation of the new boilers and generator was made possible thus alleviating the critical district power situation.

Two new single-unit, wet tubular type electrostatic precipitators, were installed to operate in parallel and clean primary washed blast furnace gas before use in the boilers. Although blast furnace gas is the only fuel installed, the four burners, two upper and two lower, are designed to handle any fuel by adding the necessary parts. Natural gas is used for the continuously burning pilots.

Control panel boards, as shown in Figure 4, consist of two individual boiler panel boards, a master panel board and a pressure reducing and desuperheating panel board. All boiler controls, which includes combustion, feedwater, furnace pressure, steam temperature, and automatic soot blowing, are of the air-operated type. Compressed air is taken from an air receiver which normally receives its air from the plant 80 to 100-psi system. However, an emergency motor driven air compressor is provided to cut in automatically in the event of low plant air pressure.

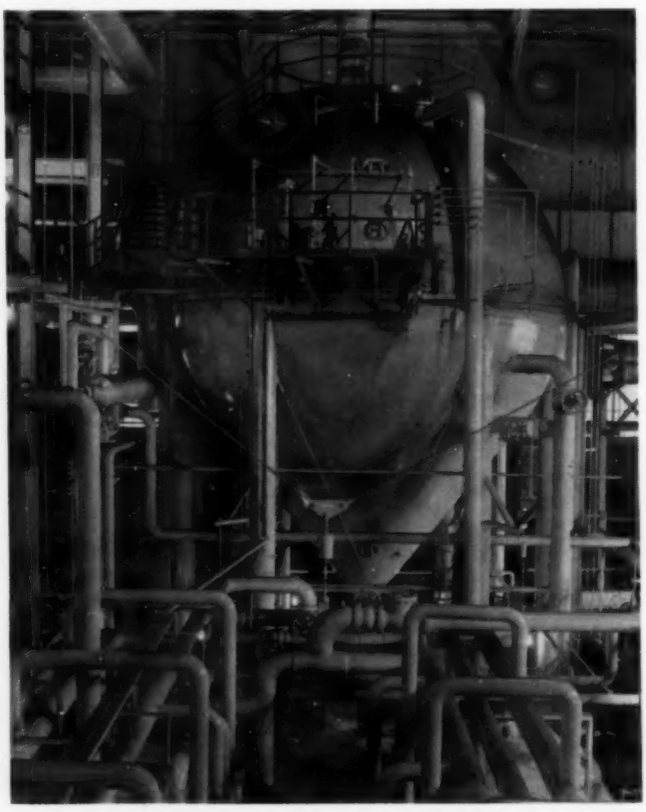
Figure 5 shows the feedwater treating facilities. The system consists of a sphericone softener to provide preliminary heating, deaeration, partial softening and clarification of the raw water entering the system; four filters arranged in parallel to complete the clarification; three zeolites arranged in parallel for complete softening; and necessary auxiliary equipment. A deaerating heater was provided for final heating and deaeration of both treated water and condensate returns.

Turbo-Generator—A new 15,000-kw (3-phase, 25-cycle, 6600-volt) topping turbo-generator, as shown in Figure 6, was put into operation in August 1953. Steam is supplied at 900-psi, 900-F, by the two new high pressure boilers, to the turbine throttle and the turbine exhausts at 280-psi, 600-F into the existing plant system. When the new generating unit is out of service or not taking full boiler capacity, high pressure steam can be passed automatically through one or more of the three pressure reducing and desuperheating stations that parallel the topping turbine. Each station has ample capacity to pass all steam generated from one boiler. Their control is air operated with pressure control from the 950 psi steam header, thus the stations operate as spillover valves.

The turbine is designed to run at 3600 rpm and is connected through a helical-tooth type reduction gear to drive the generator at 500 rpm. The use of a smaller, lower cost, 3600-rpm turbine with a geared generator offered advantages and economies not obtainable when a low speed turbine is used for direct connection to a 25-cycle generator.

The turbine is a horizontal unit having 10 stages and is furnished with the usual standard accessories and a complete lubrication system. Oil conditioning equipment is installed to maintain a constant supply of clean oil for turbine lubrication and control systems. Temperature monitors are installed in all bearings of the main turbo-generator unit to automatically and suc-

Figure 5 — Preliminary feedwater treating is done in a sphericone softener.



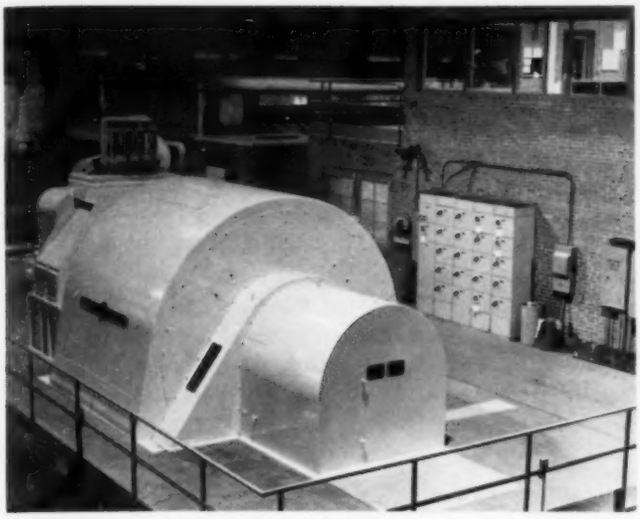


Figure 6 — Unit shown is a 15,000-kw, 3-phase, 25-cycle, 6600-volt topping turbo-generator.

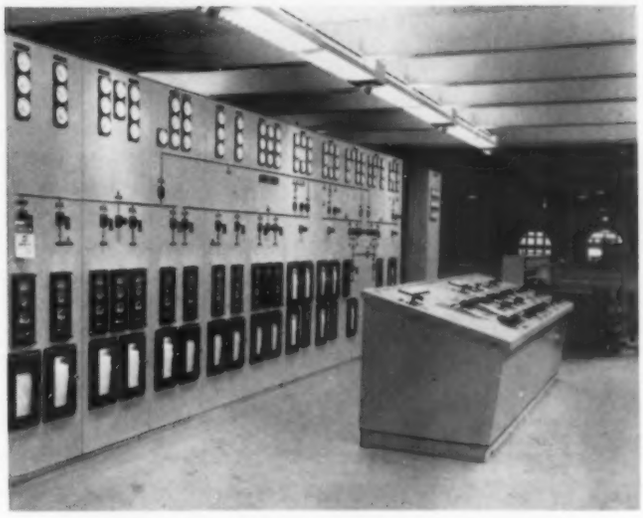


Figure 7 — Power house controls are arranged for easy operation.

cessively check the temperatures of the various bearings.

The generator is air cooled by fans mounted on the generator rotor. An air cooler is provided to cool the air required for circulation through the generator, which, due to its low speed, is more readily cooled than a standard two-pole unit.

The turbine governing system is of the hydraulic type and is interconnected with the lubrication system for the turbine, gear, generator and exciter bearings.

Switchgear — A separate building was constructed within the power house for new control and switchgear equipment for the new topping turbo-generator and the two existing condensing turbo-generators. The building is designed as a three story structure with the synchronizing bus with its reactors and feeder reactors installed on the first floor, switchgear on the second floor, and control, metering and relay equipment on the third floor. The control room on the third floor is provided with large observation windows which provide a good view of all three turbo-generators.

A benchboard is located in the control room, as shown in Figure 7, that permits synchronizing of all three generators and control of the synchronizing bus and excitation equipment. The main and auxiliary duplex boards provide control for all feeders and auxiliaries and incorporate all instrumentation, metering, relaying and alarm identification. An operators desk is provided with indicating wattmeters for all feeders, generators and total generation. A master alarm panel and a communication system are also provided. A telemetering panel was installed to furnish wattmeter indication for each of eleven feeders at the McDonald mills. A recording demand meter panelboard with selector switches permits the recording of a 5, 10 or 15-minute demand from any pre-selected feeder.

Complete protective relay schemes are provided which include differental, overcurrent, ground, power directional, loss of field, etc. The metal-clad drawout switchgear is rated at 6600-volt, 3-phase, 25-cycle, 500,000-kva interrupting capacity.

New excitation switchgear and voltage regulating equipment is provided for all three generators, which includes a spare exciter for use with any of the three generators.

A new carbon dioxide fire protection system was provided for the two old condensing turbo-generators and a similar system was installed for the new topping turbo-generator. The systems operate automatically by operation of either the fire detection thermostats or the generator differential relays.

INTERESTING SIDELIGHTS

Division of load between the three generators in relation to peaks presented a problem, as swings of 10,000 kw in less than a second are experienced. These swings are caused primarily by the McDonald mill's 43-in. hot

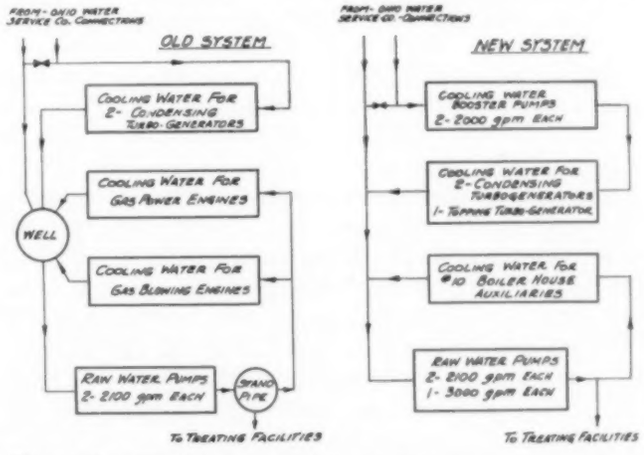

FROM - OHIO WATER SERVICE Co. CONNECTIONS
OLD SYSTEM
COOLING WATER FOR 2- CONDENSING TURBO-GENERATORS
COOLING WATER FOR GAS POWER ENGINES
WELL
COOLING WATER FOR GAS BLOWING ENGINES
RAW WATER PUMPS 2- 2100 gpm EACH
STAND PIPE
To TREATING FACILITIES
FROM - OHIO WATER SERVICE CO. CONNECTIONS
NEW SYSTEM
COOLING WATER BOOSTER PUMPS 2- 2000 gpm EACH
COOLING WATER FOR 2- CONDENSING TURBOGENERATORS 1- TOPPING TURBO-GENERATOR
COOLING WATER FOR #10 BOILER HOUSE AUXILIARIES
RAW WATER PUMPS 2- 2100 gpm EACH 1- 3000 gpm EACH
To TREATING FACILITIES

Figure 8 — Sketch shows changes in raw water system.

strip mill which demands 10,000 to 20,000 kw depending upon the product being rolled and often operates during parts of the week, when other mills are shut down causing a low system base load. Division of load is accomplished by means of a load limiting device on the topping turbo-generator which limits its maximum output and permits loading on the two condensing turbo-generators thus eliminating any change of motoring.

The use of the load limiting device created another problem due to the fact that only one fuel, blast fur-

nace gas, is available to fire the high pressure boilers. The topping turbine will attempt to operate at the load limit setting without regard to steam availability, therefore with no stand-by fuel for the boilers, it is possible to drag the boiler pressure down, which if the pressure dropped fast enough could cause water carryover. To permit maximum loading of the topping turbine, without reducing the 900-psi system steam pressure, an initial pressure regulator has been purchased and will be installed soon. This regulator will maintain a preset inlet steam pressure at the expense of kw output when and if a shortage of blast furnace gas exists.

It is interesting to note that simultaneous operation of the three turbo-generators creates an excellent steam balance, in that, the topping turbine has a steam rate of about 31 lb per kwhr which exhausts to the throttles

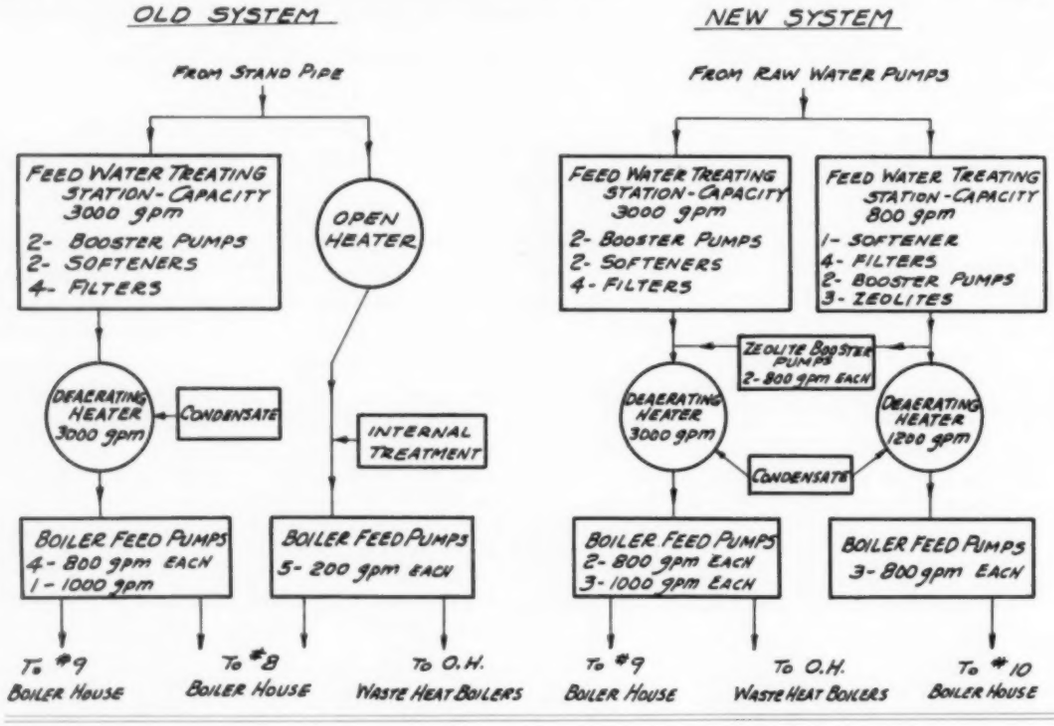


Figure 9 — It was necessary to make a number of changes in the treated water system.

of the two condensing units having steam rates of approximately 13 lb per kwhr each. Therefore, it can be said that the combined steam rate of all three generators is about 10 lb per kwhr. The turbo-blowers, boiler house auxiliaries and miscellaneous pumps provide a base load for No. 9 boiler house and provide use for the steam going through the 950-psi to 280-psi spillover, thus making it possible to so load the new high pressure boilers at all times as to use all available blast furnace gas.

Changes to the plant raw water system, as shown in Figure 8 were occasioned as a direct result of the new generator and boilers and should be of interest. Previously, raw water flowed through the coolers of the two condensing turbo-generators under Ohio water service supply pressure, which at times dropped dangerously below 10 psi. This water drained into a hot well. Raw water also went directly to the hot well through another supply line. From this well, it was pumped into a standpipe which supplied water for all of the Ohio works boilers and cooling water for gas engines. The cooling water coming from all the gas engines drained back into the well thus making a loop cooling system. In the new system, booster pumps pick up the water as it enters the plant and pump it through all coolers on the three turbo-generators from which it goes to the suction side of the raw water pumps which supply water for all the Ohio works boilers. Thus the old standpipe and well have been eliminated along with the danger of low water pressure. A line from the discharge of the circulating water pumps on the condensing turbo-generators, to the suction of the booster pumps, serves as an emergency cooling water supply.

An existing 96-in. blast furnace gas main was also utilized that runs from the blast furnace area to a header running between the power house and boiler house. Gas washers, now removed due to the new precipitators, cleaned the gas for the seven gas power engines and four gas blowing engines. A gas holder, located at the washers and also removed, regulated the gas pressure in the header for proper ignition of the engines. An operating problem was foreseen, that during the start up period of the new boilers and generator, and before the old gas engines could be shut down, an extreme gas pressure variation would exist in the blast furnace gas header due to increased and variable gas flow caused by the new boilers. This would cause the engines to lose ignition. The gas holder could not be utilized because the higher pressure, necessary due to increased flow, would blow the seals. To solve the problem an air operated "swing through" type, butterfly valve was installed downstream of the precipitators with its control impulse point located in the header between buildings close to the gas engine take-offs.

Every new installation invariably has something happen that is unusual. The new boilers have pendent type superheaters that are non-drainable so that once water is added for the hydrostatic test, it will lay in the superheater tubes until the boiler is fired. Usually the hydrostatic test is made before the water treating facilities are ready for operation, thus untreated water is used, but without concern of damage due to corrosion

because the boilers are normally fired within four to six weeks. However, immediately after the hydrostatic test of these new boilers, all work was stopped due to a strike. This caused considerable concern, as the length of the strike could not be determined, so our feed water consultant recommended the use of hydrozene hydrate to remove any oxygen that is present in the water. One pound of concentrated hydrozene hydrate per 1000 gal of condensate was used, giving a concentration of approximately 50 ppm. This solution was pumped through the superheater of each boiler six times thus tending to flush the hydrostatic test water out and leave a small concentration of hydrozene hydrate to guard against corrosion. Before starting the boilers, a sample was taken from the superheater header drain that indicated there was still hydrozene present but at a lower concentration than originally put in. Therefore, it is believed that no corrosion took place. It may be interesting to know that the manufacturer of hydrozene hydrate is presently conducting tests endeavoring to prove that hydrozene hydrate will do a better job, and cheaper, than sodium sulphite in removing oxygen from boiler feed water.

Changes in the plant treated water facilities, as shown in Figure 9 were occasioned as a direct result of the new boiler house and should be of interest. Since it is desirable to favor the new high pressure boilers with all available condensate, the makeup in the feed water for No. 9 boiler house was increased from 50 to about 90 per cent. This did not cause capacity of the old treating facilities to be exceeded because they also supplied No. 8 boiler house, which was abandoned, but it did leave the boilers in No. 9 boiler house a poorer grade of feed water than before. To remedy this, a 12-in. line was run to connect the new treating facilities to the deaerating heater at No. 9 boiler house, thus permitting the normal excess capacity of zeolite water to be used at No. 9 boiler house except when condensate is lost due to a turbo-generator, and/or, a turbo-blower being out of service, making it necessary to use all of the zeolite water at No. 10 boiler house. In addition, the old treating facilities, which consist of two lime-soda softeners and four filters, have been modernized as much as possible to attain a better treated water. The abandonment of No. 8 boiler house and replacement of two boiler feed pumps with pumps of larger capacity, made it possible to supply boiler feed water to the open hearth waste heat boilers from the old treating facilities, thus abandoning a treating and pumping station and providing better water for the open hearth boilers.

During construction of the topping turbo-generator and control and switchgear house, it was necessary to keep the gas power engines operating in order to maintain production. These engines were operating within a few feet on both sides of the construction site. During construction, any blast furnace gas leaks that caused the carbon monoxide content of the ambient air to exceed the allowable limits for a working area was not permitted. A safety man was on duty, whenever workmen were in the area, to take carbon monoxide readings and evacuate all men from the job if concentration exceeded 0.01 per cent. It was determined that, within a week, four roof ventilating fans, with a capacity of 80,000 cfm at ½-in. static pressure, and a centrifugal blower of 100,000-cfm capacity at 6-in. static pressure that had been delivered for another ventilating job could be utilized, to make certain that the surrounding area was safe at all times.

A thorough knowledge of equipment is a prerequisite to successful operations. Realizing this and the fact that high pressure boilers and a topping turbine were new to everyone concerned, a training program was planned and successfully administered consisting of the following:

1. *Two week training course*—All operating personnel, including turn foremen, were relieved from their former duties two weeks in advance of the expected starting date to attend the training course eight hours a day. The first week consisted of a general description of the entire project and its operation coupled with field inspection. The second week, consisting of a more detailed study of the major pieces of equipment, was given by the different manufacturers involved.
2. *Training manual*—All personnel attending the course were given a personal copy of all material used in the class room.
3. *Checking out and testing equipment*—All operators assisted the manufacturers in the checking out and testing of the new equipment before operation.
4. *Double crews* — The operators worked twelve-hour shifts in order to double up their crews the first few weeks of operation, thus each boiler had the individual attention of a full crew.
5. *Engineering assistance*—The power and fuel division had men on each turn for several weeks to offer engineering assistance and observe preliminary operations, thus helping to solve the many minor operation "bugs" that occur when starting a new boiler house.

Since the operation of this new boiler house and associated equipment has been relatively trouble free, the cost of training the men seems to have been fully justified.

DISCUSSION

PRESENTED BY

R. W. WORLEY, Power Engineer, United Engineers and Constructors, Inc., Philadelphia, Pa.

J. P. KATZENMEYER, Project Engineer, United States Steel Corp., Youngstown, Ohio.

JOHN J. ALEXANDER, Superintendent Electric Power and Steam, Republic Steel Corp., Cleveland, Ohio.

HARRY I. RIEGEL, Superintendent of Utilities, Kaiser Steel Corp., Fontana, Calif.

W. B. WILSON, Manager, Power Generation Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

E. T. MORTSON, Superintendent Power and Fuel, National Works, National Tube Div., United States Steel Corp., McKeesport, Pa.

R. W. Worley: The author is to be commended for his thorough presentation of engineering details pertaining to this project; this leaves little to be added.

However, there are a few items in which this group may be interested:

1. In a steel works that produces its own blast-furnace coke and operates its own blast furnaces, it is theoretically possible to produce all required power and steam from the heat potentials released in the various processes. Availability of process waste or by-product energy constitutes the primary reason for the existence of large power stations in the steel works.

First in the sequence of producers of by-product heat is the coke oven. For every ton of coke produced, there will be about 8000 cu ft of surplus gas with a heat value approximating 550 Btu per cu ft and about 145 lb of coke breeze with a heat value of about 11,000 Btu per lb. The gas finds use for various metallurgical-heating purposes in the mill, such as open hearth and reheating furnaces. Surplus gas often is sold for local domestic distributors. About 13 gal of tar are also produced which may be used as fuel or further treated to obtain valuable by-products.

The blast furnace is the largest producer of waste heat. The gas issuing from the furnace top will contain from 9 to 14,000,000 Btu per ton of iron produced. About 25 to 30 per cent of this gas is used for stove heating, but there remains 6 to 9,000,000 Btu per ton of iron which may be used for underfiring coke ovens, in boilers to make steam, in internal combustion engines, or, in the near future, in gas turbines.

Speaking broadly, there is sufficient heat energy in the excess blast-furnace gas to produce 4500 to about 6800 lb of steam per ton of iron tapped, about 1000 to 1300 lb of this steam will be used to provide air for the blast furnace, which still leave adequate steam to produce 220 to 440 kwhr per ton of iron. This generally will be adequate for steel mill electric power requirements.

2. The use of a cooling tower for circulating water supply, installed immediately adjacent to a river of apparently adequate flow, seemed very unusual at the time, especially when no site was available adjacent to usage point requiring expensive connecting water mains. However, original studies indicated and have been proven correct by actual operating experience, that the elimination of excessive maintenance costs and loss of production required to clean condensers, very easily justified the cooling tower installation. Since this installation, there have been several instances of other cooling tower installations adjacent to rivers.

3. The author has referred to the use of steam-driven auxiliaries (and I quote) "to operate from the plant 280-psi steam system which saved equipment and piping cost while utilizing a *more dependable* steam source and enabling start-up from other plant boilers. Steam auxiliaries were used exclusively due to *their reliability* and the need for 5-psi exhaust heating steam." I agree that it is very convenient to start up steam auxiliaries when the auxiliary steam supply is cross connected to other boiler houses, and that steam auxiliaries are desirable when 5-psi exhaust is needed for feedwater heating; however, I do want to point out that this is ordinarily a question of economics and preference and not necessarily dependability. Many power stations are in operation where only electrical-driven auxiliaries are installed. Also, it is entirely possible and feasible to provide steam-driven auxiliaries supplied only from the immediate steam-generating unit without reliance on outside steam supply.

J. P. Katzenmeyer: I agree with Mr. Worley when he states that many power stations depend solely on motor driven auxiliaries and that it is feasible to provide steam driven auxiliaries supplied only from the immediate steam generating unit. However, at our plant, we felt that it was highly desirable to use the 280-psi steam source for auxiliary drives from the economy viewpoint due to the lower equipment cost (950-psi vs 280-psi steam drives) and the need for 5-psi exhaust steam; and from the reliability viewpoint due to cross connecting to another boiler house thus giving us an added measure of dependability. Also, we have an isolated 25-cycle system with no connection to other plant systems as exists in the Monongahela Valley plants of United States Steel Corp. Therefore, if motor operated auxiliaries were installed, they would be dependent entirely upon one power house.

John J. Alexander: Mr. Katzenmeyer has presented a very complete description of the steam generating, blast furnace blowing and electric power generating facilities at Ohio works. I was impressed by his statement that "Ohio works found itself with power, steam and blowing facilities that were inadequate to meet the growing demands imposed upon them." All too frequently we fail to recognize and take steps to correct this situation. His paper relates a well engineered plan to replace the obsolete, inadequate facilities with modern efficient equipment. Careful engineering permitted the best use of existing structures. It is apparent that many operating problems due to construction work were anticipated and difficulties in operation were avoided by temporary installations.

Power equipment is frequently selected and installed to satisfy a local condition or choice.

While I agree with the selection of turbine driven auxiliaries for reliability, I have noticed that the cost of producing steam is usually increased at fractional boiler load due to surplus exhaust steam from auxiliary turbines. I believe that dual drives or spare motor driven auxiliary equipment can be justified for operating economy and reliability of large steam generating units for steel plants.

I noted in Figure 4 that the boiler and PRV controls were placed some distance apart. Does this arrangement have any advantage compared to a central panel or control room?

Also since the blast furnace gas volume is reduced by each check, stop or cast of a blast furnace, why was it not advisable to install coal or oil burners on the 950-psi boilers to permit base load operation of the most efficient steam generating units?

Has installation of the turbo-blowers, topping turbo-generator and 950-psi boilers resulted in any reduction in the cost of producing steam, electric power and blast furnace blowing?

J. P. Katzenmeyer: Mr. Alexander's first question was: "Is there any advantage in having the boiler and pressure reducing control on separate panels instead of a central panel or control room?" At the Ohio works we believe that the individual boiler controls should be on separate panels to avoid any possible confusion on

the part of the operator. As for the master panel and pressure reducing panel, they could be conveniently combined, but in this case the equipment was being supplied by two different manufacturers and we felt it was best not to have a split responsibility.

Secondly, he has asked the question, "Since the blast furnace gas volume is reduced by each check, stop or cast of a blast furnace, why was it not advisable to install coal or oil burners on the 950-psi boilers to permit base load operation of the most efficient steam generating units?" Table III shows that there is sufficient blast furnace gas available under 4, 5, or 6 furnace operation to operate the new 950-psi boilers at rating. If there is a reduction in blast furnace gas volume, it is taken at No. 9 boiler house where there exists pulverized coal firing equipment. However, at a three blast furnace operating level, it would be necessary to reduce rating on the new boilers beyond the amount that could be made up by coal at No. 9 boiler house. Therefore, serious consideration is currently being given to the installation of auxiliary fuel oil-firing facilities. It can be noted in Figure 3 that the new boilers are flat bottomed, therefore it will never be feasible to use coal as a secondary fuel.

His third question was, "Has the installation of the turbo-blowers, topping turbo-generator and 950-psi boilers resulted in any reduction in the cost of producing steam, electric power and blast furnace blowing?" On a plant basis, the cost of producing steam has been substantially reduced due to the utilization of blast furnace gas that was wasted in the past, and due to the abandoning of old coal-fired boilers. Power costs were reduced primarily due to steam costs as the Btu used per kwhr produced at the Ohio Steel works has been reduced by better than 20 per cent. Blast furnace blowing costs were reduced as the turbo-blowers replaced steam engine blowers and a reduction in excess of 40 per cent in steam cost per blast unit was realized.

Harry I. Riegel: Our problems differ greatly in that we generate no power whatsoever. We do have the blast furnace gas problem. We find that electrostatic precipitators do a wonderful job of cleaning the gas for both underfiring ovens, heating blast furnace stoves, and also, keeping boiler burners in excellent shape.

Our experience has been that a boiler once placed on the line should stay on the line for approximately one year. We pick the one-year period because we are required to have an annual inspection.

We have a unique problem in our water system in that we are in a water scarce area. Our water treatment for the boilers has been quite extensive although simple. We have had the first boiler in operation approximately 12 years and to this date have not lost a water-tube due to water conditions nor has it been necessary to turbine any tubes.

As for the use of cooling towers in conjunction with steel mill operation, I believe our plant practice goes to the extreme. We do not have a river for our water supply, nor do we have a river in which to dump our refuse. This introduces another problem. We are accused of wearing the water out. We have to purchase water and treat it, use it, retreat, reuse, and eventually evaporate or blow down on our slag pits at the blast furnace.

W. B. Wilson: Mr. Katzenmeyer has done an excellent job in describing the importance of utilizing higher initial steam conditions for power generation and blast furnace blowing applications in our steel industry. This paper is very timely. At the present time, operating costs in many steel mills are too high because of the low efficiency and high maintenance of existing, obsolete generating and blowing equipment. The installation of high pressure turbine generators and for turbo-blowers to "top" the mills low pressure steam system can reduce maintenance costs and relieve the critical shortage of cooling water that exists in many mills. Of even more importance is the great saving in fuel consumption that will result because of the improvement in overall plant thermal efficiency.

Even though Mr. Katzenmeyer did not specifically mention the dollars saved in annual operating costs due to his installation of a topping turbine, these savings can run into hundreds of thousands of dollars in some mills. Many of you have already made studies of your own mill power system and are aware of the savings that can be realized. I would strongly urge all of you to go back and review your own mill system—you may be surprised at the savings you can realize by adopting higher steam pressure with turbines to top the low pressure steam systems. In many cases, old inefficient boiler plants can be retired, as was done at Ohio works, with a large saving in fuel cost and the increasingly important item of savings in operating labor.

So much for the importance of studying the overall system, present as well as future, when an expansion or replacement of obsolete equipment is being considered, I would like to say a few words about the specific solution described in Mt. Katzenmeyer's paper.

Based on the figures for 1953 shown in Table II, there is still a large use of 150-psig steam with 460,000 lb per hr being supplied through the reducing valve from 280 psig. Expansion of this amount of steam from 280 psig to 150 psig could generate over 6000 kw of "by-product" power. I am sure this condition has been carefully evaluated by Ohio works. I would like to ask Mr. Katzenmeyer if this is a temporary condition—for instance, it is expected that the use of 150-psig steam will be appreciably reduced due to retiring steam engine blowing tubs or mill drives in the foreseeable future?

If the data in Table II is typical, then a logical question might be—why not select the topping turbo-generator to exhaust at 150 psig instead of at 280 psig? Or maybe select one or more of the new turbo-blowers for operation with initial steam conditions of say 900 psig, 900 F exhausting at 150 psig? Based on a fuel cost of 20 cents per million Btu about $5.00 coal fuel chargeable to a "topping" turbo-blower with an output of 11,000 hp would be almost $100,000 less per year than it would be for a low pressure condensing turbo-blower.

If plans are to eliminate a large part of the 150-psig steam use, then selection of the condensing turbo-blowers with 600 to 900-psig initial steam pressure might have been considered to improve the overall power plant efficiency and reduce the amount of cooling tower capacity required. This arrangement would have meant more high pressure boiler capacity but might permit retirement of any obsolete 280-psig boilers.

All operating conditions must be factored into the final selection of higher initial steam pressures and temperatures but the savings that can often be realized are enough to really make management listen to your story.

Now for a word about 25-cycle vs 60-cycle generation. I know that Ohio works based their selection of 25-cycle on a very careful study of the future plans for power supply and utilization as well as their immediate need. Electrical equipment manufacturers are ready to build generators to meet the requirements of your particular application. When new generation is contemplated in a 25-cycle plant, the question always arises as to whether or not 60 cycles should be considered. If a new block of load is to be added, this can be made 60-cycle with its recognized advantages. If 25-cycle generators are being replaced or retired, this is a logical time to look over the 25-cycle utilization equipment to determine if a corresponding block of this can be replaced or modernized due to obsolescence. If such a block of load can be changed to 60-cycle, this then becomes the ideal time to start a 60-cycle generating system. I know of no one who has taken this step to 60 cycles that has ever regretted it.

J. P. Katzenmeyer: Mr. Wilson has brought out a good point in connection with Table II that needs further explanation. He notes that there is 460,000 lb per hr of 150-psi steam being supplied through a reducing valve from the 280-psi system and asks if this is a temporary condition. With reference to Table II, note that the major requirements for 150-psi steam come from the blowing engines (200,000 lb per hr) and the steel plant (400,000 lb per hr). In a breakdown of the steel plant use, you will find that the major portion is consumed by steam engine mill drives. In the not too distant future these mills will be motorized and the remaining steam blowing engines will be replaced with turbo-blowers, thus the 150-psi requirements will be greatly reduced and the 280-psi requirements increased creating a good plant steam balance.

E. J. Mortson: I might add in regard to turbo-blowers we have recently placed in operation at National works two topping turbo-blowers for blast furnace use. So far we have found them very satisfactory. We topped from 850-psi pressure to 150-psi pressure 400 F with pressure reducing station operating in parallel with the turbo-blowers.

ONE HUNDRED PER CENT SINTER BURDEN AT GARY WORKS*

▲ THE problem of physical preparation of fine or inferior Mesabi ores has matured in recent years into a full partnership with other branches of steelmaking. Much study, research, and testing has gone into attempting to decide which method of preparation produces a burden material most suitable for blast furnace use. Many tests have been conducted comparing ordinary ore burdens with burdens including sinter, nodules, or pellets. However, in this country, relatively little work has been done on determining how large a percentage of these materials can be used successfully in the blast furnace.

Some European steelmakers have been driven by necessity to the use of 80 to 95 per cent sinter in their burdens. In Sweden, great resources of ores are available, but there is no coking coal and much of the ore is a fine concentrate of hard to reduce magnetite. Sintering these ores enables the operators to use a rich-well-prepared burden, thus realizing a great saving in coke consumption.

In England, certain plants were using carbonate ore containing as high as 60 per cent fines. Sintering these ores accomplished three results: (1) agglomerating the fines, (2) calcining the carbonates, (3) driving off sulphur. At Appleby-Frodingham, 95 per cent of all the ore is now sintered, and the improvement in operations show this plant's production was increased from 576 net tons daily to 747 while coke rate dropped from 2266 to 1751 lb per net ton.

The United States Steel Corp., interested in the excellent results obtained from using high percentages of sinter in many European blast furnace burdens, felt that a test should be conducted on one of its furnaces to determine whether similar results could be achieved. This information was desirable also to justify plans for future expansion of sintering capacity with the corporation. It was decided to conduct this test at Gary Works because adequate sintering-plant capacity was available to support a 100 per cent sinter burden on one furnace without affecting the other furnaces seriously. In order to conduct a fair trial, it was felt to be essential to use a furnace whose lines were known to be intact; therefore, No. 12 furnace was chosen, as she had been blown in July 20, 1953, after a stack relining. This furnace has a hearth diameter of 25 ft, 16 tuyeres, and a working volume to hearth area ratio of 68.

During this test it has been proved, to the satisfaction of the investigators at least, that a blast furnace can be operated successfully and efficiently on a burden of 100 per cent sinter. Whether it is more economical to operate furnaces in this manner, at the expense of losing sinter on other furnaces, is a matter for further study. The results indicate a definite need for more sintering-plant capacity, to attain the most efficient use of the raw materials now available.

Specifically, the following information was derived from this test:

1. It was not necessary to provide a long period of adjustment when changing the burden to include a high percentage of sinter.
2. There was practically no change in the temperature of the iron produced.
3. High blast temperatures were demanded for smooth operation.
4. Lower wind volumes were required.
5. There was a tendency to build up on the walls, requiring periodic cleaners.
6. There was a definite increase in iron production, lower coke rate, and lower flue dust production.
7. The thermal load of the furnace was significally decreased.
8. When higher percentages of sinter are employed, it is extremely important to have close control of the sintering operation.

*From paper by R. W. Sundquist, Division Supt., Blast Furnaces, Gary Steel Works, U. S. Steel Corp., presented at Annual Conference of the AIME Blast Furnace, Coke Oven and Raw Materials Committee, Philadelphia, Pa., April 18, 1955.

A Study of Failures in Iron Work Rolls

. . . . by controlling operations carefully, perpendicular breaks in the body of the roll can be minimized, particularly during the critical warm-up time of a mill . . . . spalling seems to be due to high radial stresses set up in the roll by temperature conditions . . . .

By CHARLES F. PECK, JR.
Associate Professor
and
FREDERIC T. MAVIS
Head, Department of Civil Engineering
Carnegie Institute of Technology
Pittsburgh, Pa.

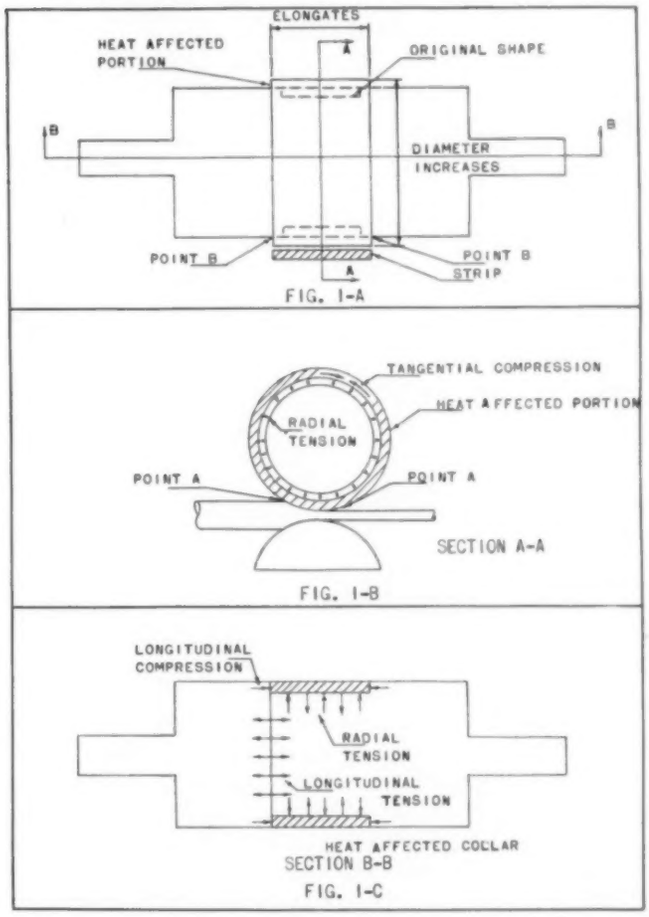
▲ THIS paper presents the second phase of the study of fractured iron work rolls being carried out at Carnegie Institute of Technology under the joint sponsorship of the Association of Iron and Steel Engineers and the Roll Manufacturers Institute. In the first paper* a method of analysis was presented which gave the radial and tangential temperature stresses in a hypothetical roll. The work presented in this paper extends these studies to the temperature stresses in an actual roll. Graphs are presented which show the change in the temperature and major temperature stress components as a "cold" roll is heated during early rolling. The solution is based on roll temperatures measured at Bethlehem Steel Corp., Sparrows Point, Md.

Stresses in the same roll which are set up by the mechanical work are given insofar as present data will permit. Primary pressure stresses at the point of contact between strip and roll and between backup roll and work roll are determined analytically as are the bending stresses. Internal stresses within the work roll, other than those set up by the primary bending, are analyzed photoelastically.

A combination of all the stresses, including those caused by temperature, clearly shows tensile stresses which could become high enough to cause cracks in the brittle cast iron. These cracks form in such a manner that they could cause *spalls* and *breaks in the main body of the roll*, two of the major types of roll failure.

Acknowledgments — The work presented in this paper was supervised by Dr. Charles F. Peck, Jr. under

Figure 1 — Sketches show how temperature induces stresses in work roll.



*Numbers in parentheses denote numbers in bibliography.

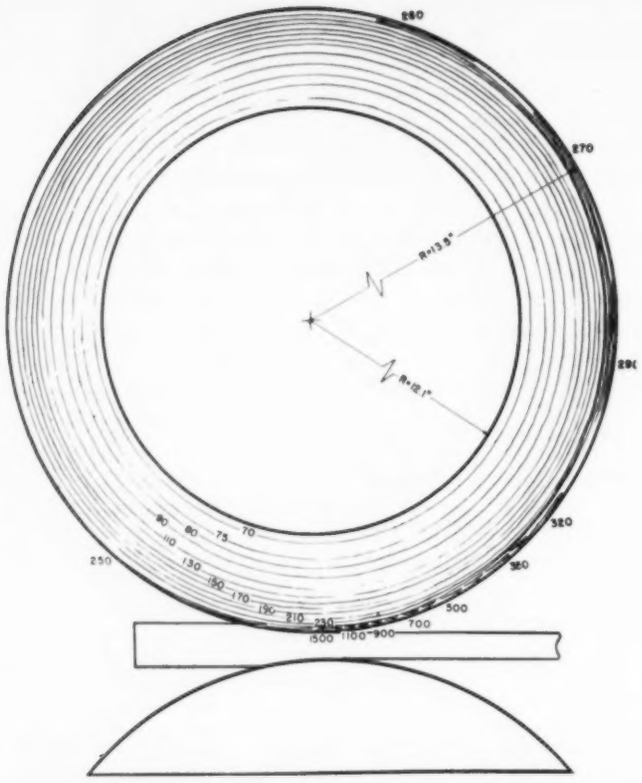


Figure 2 — Isotherms are given after 8 revolutions on Stand 7 of a 68-in. mill.

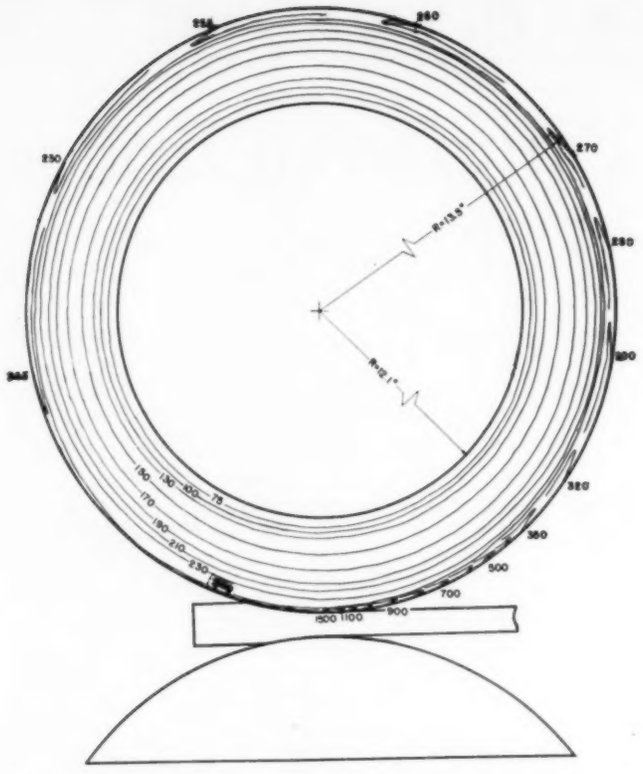


Figure 3 — Isotherms are given after 100 revolutions on Stand 7 of a 68-in. mill.

the administrative direction of Dr. F. T. Mavis. Juan M. Bonetti, Pre-Doctoral Fellow and W. J. Green, R. A. Boschetto, B. G. Bertocci and A. M. DiGioia, Jr., students in the Civil Engineering Department, carried out the numerical calculations.

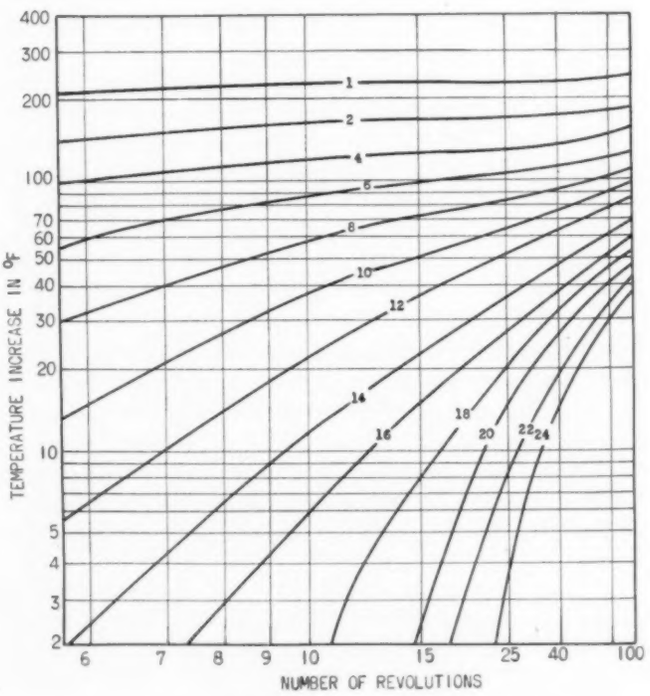
Special thanks are due to Mr. I. E. Madsen of the Association of Iron and Steel Engineers and to Mr. J. J. Marsalka of the Roll Manufacturers Institute who, with the members of the joint committee of the Roll Manufacturers Institute and the Association of Iron and Steel Engineers, supported the study directly and through their liaison with roll manufacturers and steel producers. Mr. Louis Moses of Bethlehem Steel Corp. was particularly helpful in obtaining the roll temperatures.

Temperature Stresses—The problem of temperature stresses in work rolls is similar to the stress problem which arises when a collar is "shrunk" onto a shaft except that in our case the collar, as represented by the heat-affected portion of the roll, is expanding away from the remainder of the roll both radially and longitudinally. Figure 1-A shows the shape which the shell would take if it were unrestrained. However, internal stresses are set up in the roll which keep this change in shape from occurring. Figures 1-B and 1-C illustrate these stresses.

Early studies indicated that the radial tension stresses shown in Figures 1-B and 1-C are greatly increased by surface temperature gradients. Sharp gradients occur around the roll at points A in Figure 1 (ahead of and behind the contact area) and along the roll at points B, (the edge of the strip), making these points critical for radial tensions or spalls.

Before analyzing the stresses, the temperatures in the roll were found in the manner described in the first paper [3a] based on measured surface temperatures. The surface temperatures were measured on No. 7 stand of the 68-in. mill, Bethlehem Steel Corp., Sparrows Point, Md., by means of a brush type thermocouple developed by the corporation.

Figure 4 — Temperature distribution is given on a radial line just after contact with the sheet. Numbers on curves denote distance into roll in increments of 0.07 in.



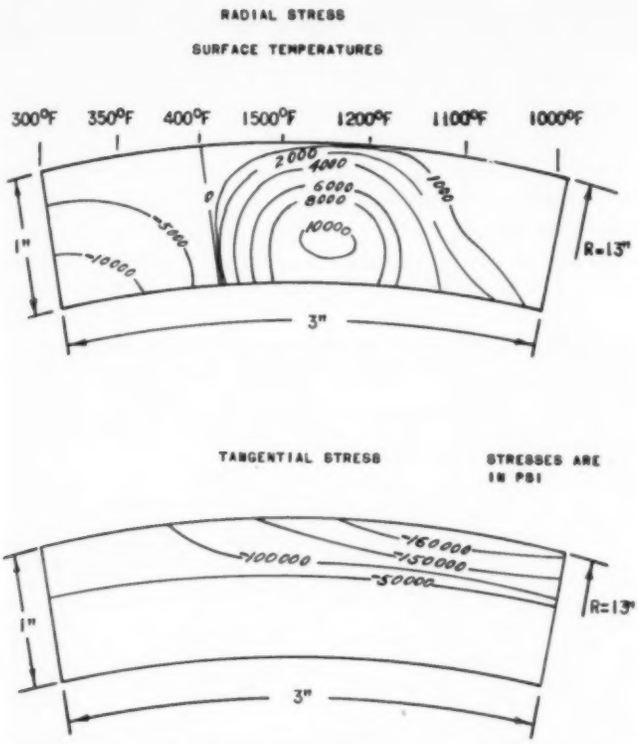


Figure 5 — Temperature stresses due to a circumferential temperature gradient are given after 100 revolutions of the roll.

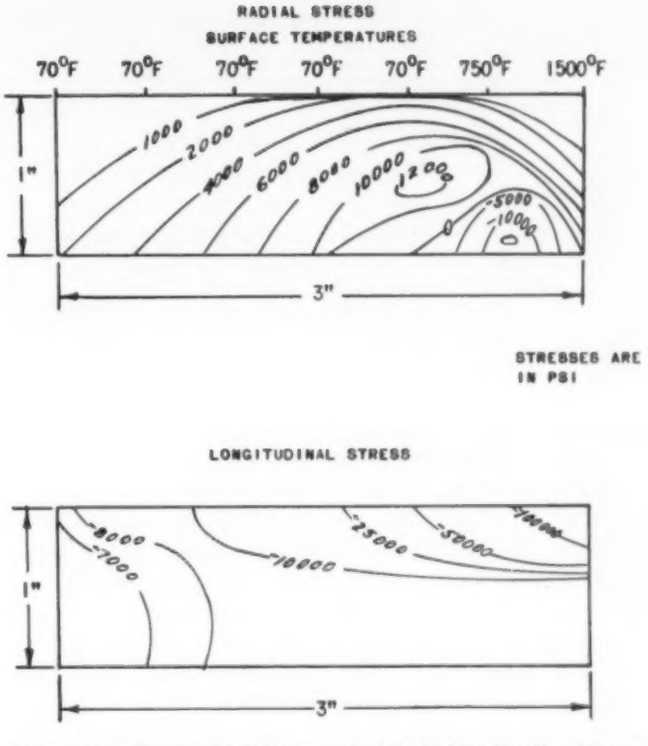


Figure 6 — Temperature stresses due to longitudinal temperature gradients at the edge of the strip are given after 100 revolutions.

Figures 2 and 3 show the temperature distributions in a cross section of the roll after eight and 100 revolutions respectively. The temperatures on the surface of the roll were those *measured*. Figure 4 shows how the temperature increases at points on a radial line into the roll at any time after rolling starts. Figure 4 may be used to determine temperature distributions similar to Figures 2 and 3 for any duration of rolling.

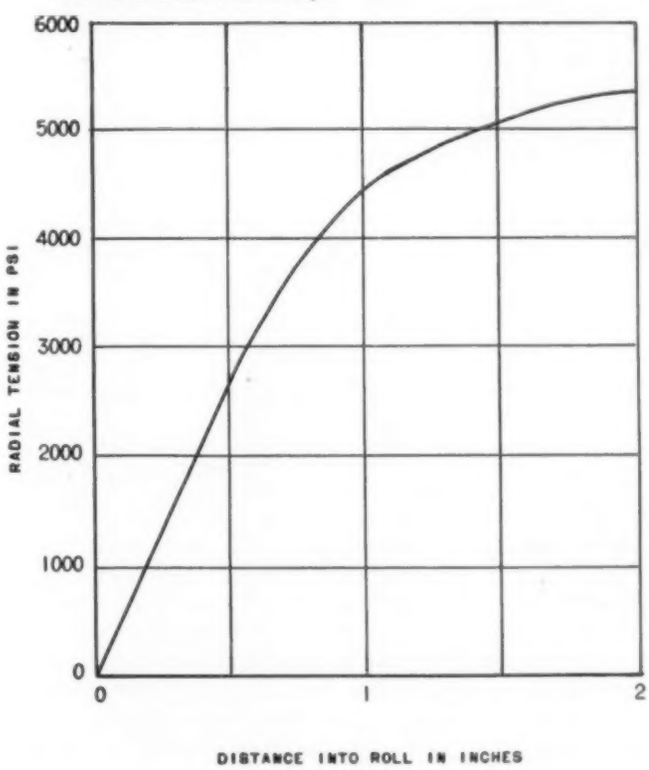
The stresses caused by the surface gradients were determined by the procedure outlined in our report of September 1, 1953.[3b] Figure 5 shows the stresses set up in the roll by the circumferential temperature gradient existing after 100 revolutions. Figure 6 shows the stresses set up by the longitudinal gradient at the edge of the strip after 100 revolutions. These stresses must be combined with other major components of temperature stress which are illustrated in Figure 1.

The major radial stress is determined by considering the outside shell of the roll as a ring. As this ring is heated it expands; and if it were not restrained it would separate from the main body of the roll. Radial tensile stresses are set up since the ring remains an integral part of the roll. The magnitude of these stresses at different distances into the roll, after 100 revolutions, is shown in Figure 7.

Figure 8 shows the longitudinal tension stresses at various distances into the roll for the first 300 revolutions of the roll. These stresses were computed by allowing the heated portion of the shell to elongate and computing the longitudinal compression force necessary to return the shell to its original shape. An equal and opposite longitudinal tension force must be applied to the remainder of the roll. This force sets up tensions of varying amount in the rest of the roll. At 100 revolutions the maximum stress occurs 1¾ in. into the roll and is 24,000 psi tension. This must be combined with the bending stress which is discussed later in the paper.

Refer again to Figure 1. The critical radial temperature stresses occur at points A in Figure 1-B and points B in Figure 1-A. At points A the radial stress caused

Figure 7 — Radial tension stresses are given after 100 revolutions for points in roll where surface of roll is not in contact with the strip.



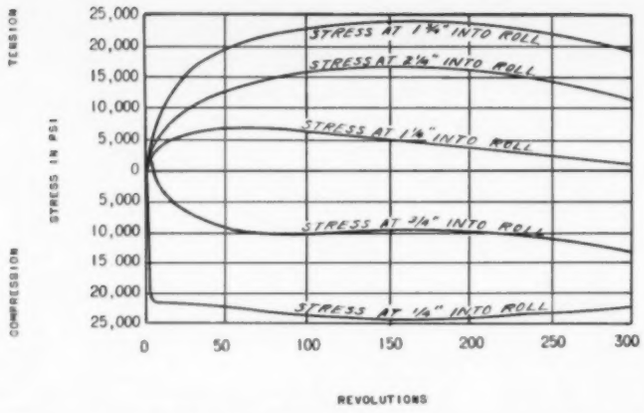


Figure 8 — Longitudinal temperature stresses are given at points in the roll where surface of roll is not in contact with strip.

by the surface gradient at a depth of ¾ in. is 10,000 psi, from Figure 5. Add to this 4,000 psi from Figure 7 and the total stress at points A tending to cause spalling is 14,000 psi. It must be remembered that this is the *temperature stress* only and must be added to the local stresses due to rolling pressures. This will be discussed later in the paper.

At points B, the edges of the strip, we have sharp surface temperature gradients. From Figure 6, the

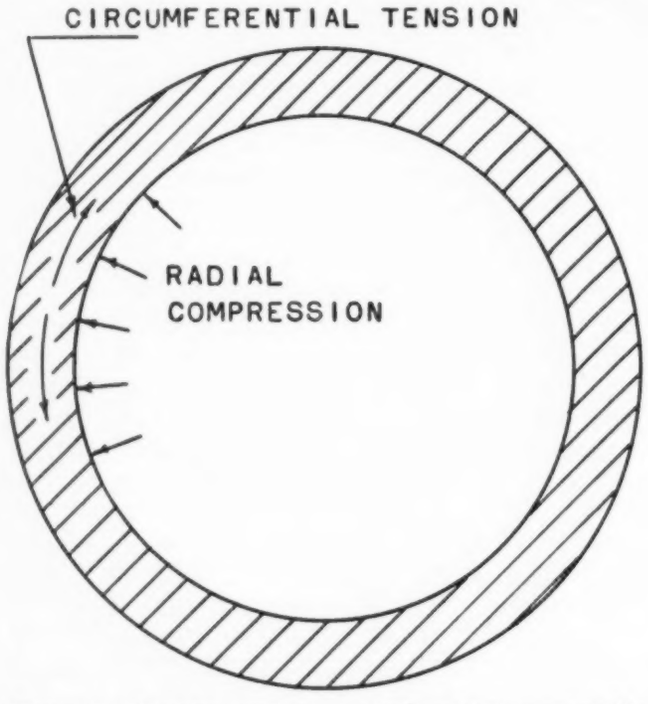


Figure 9 — Sudden surface cooling created appreciable stresses in the roll.

maximum radial stress is 12,000 psi and from Figure 7 the stress is 4000 psi at a corresponding depth of ¾ in. Again these must be added to the rolling pressure stresses. These temperature stresses may not in themselves be large enough to cause cracking in the roll.

One tension test of a coupon cut from an actual roll has been made. This test showed the material to have a tensile strength of 58,000 psi with *no* ductility. However, as will be shown later, the temperature stresses will be increased by bending and local rolling pressures and can contribute materially to spalls and perpendicular breaks.

Splits in the body of the roll have seldom been attributed to temperature stresses. However, during the past year an interesting case of a split roll was called to our attention. This roll was used for a short time in a mill where the cooling water was not applied to the roll. The mistake was discovered before the roll broke in a "normal" manner due to the excessive surface heating. The water was turned on causing the outside of the roll to shrink suddenly. Figure 9 illustrates the

Figure 10 — Split failure in the roll was probably caused by sudden surface cooling.

manner in which circumferential tension stresses are set up. If these stresses are high, the roll may split as shown in Figure 10. The roll shown might have been saved if it had been allowed to cool slowly instead of being "quenched" on the surface with cooling water.

Rolling Pressures—Figure 11 shows how the stresses in the roll vary with rolling pressure. Imagine the roll as a box of putty. If the center of the putty is pushed in, a mound builds up around the edge of the depressed

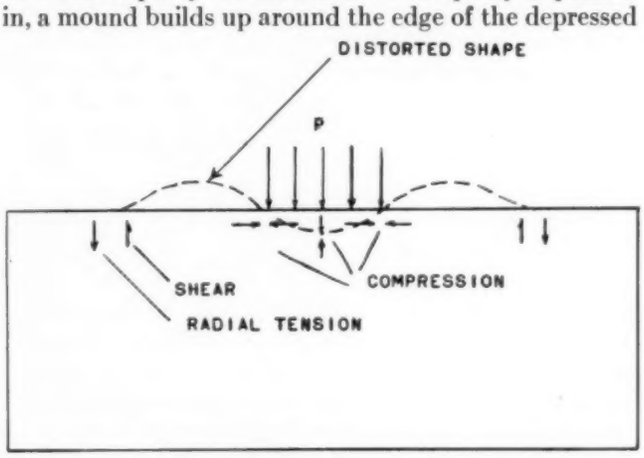
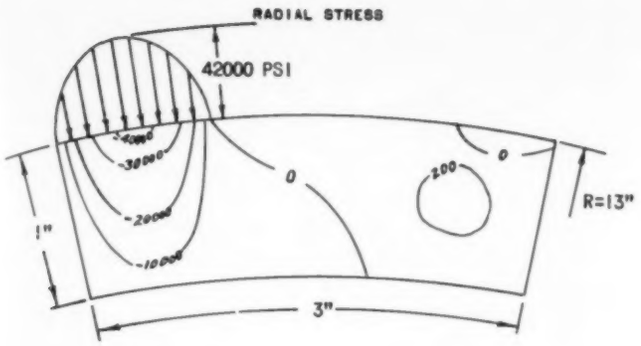


Figure 11 — Sketch indicates shape roll tends to take when subject to pressure.

region. As this mound rises it "pulls" the surrounding material setting up radial tensions.

Before analyzing for the magnitude of these local radial tensions, the separating forces acting between the roll and sheet must be determined. Table XVIII of "The Modern Strip Mill"[1] gives the separating force as 38,600 lb per in. of strip width and a length of



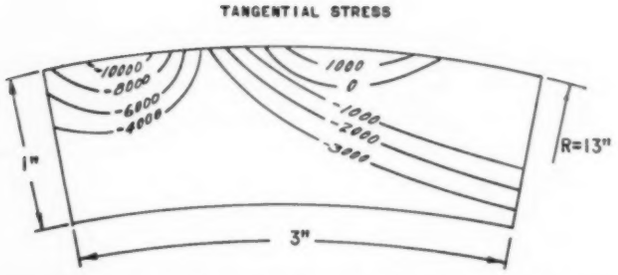


Figure 12 — Sketch shows stresses in roll parallel to direction of rolling. Tensions are low.

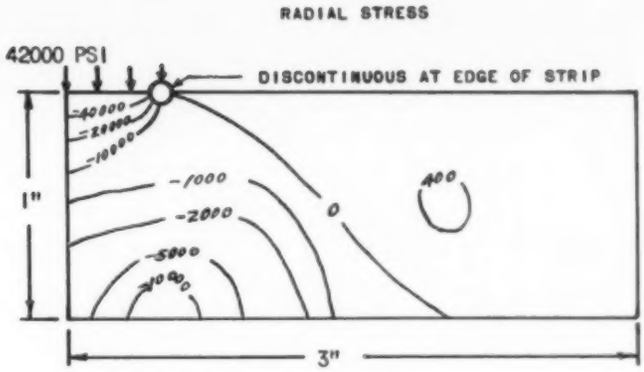
contact of 1.37 in. for a stand comparable to the one for which the temperature readings are available. However, the table does not show the distribution of this load either along the roll or in the 1.37-in. length of contact. Experiments by Siebel and Lueg[4] show that the load is distributed uniformly along the axis of the roll and approximately parabolic around the roll.

Figure 12 shows on a section of the roll parallel to rolling, how the stresses depend on the *normal* rolling pressure. These stresses appear quite low. The radial tension of 200 psi is certainly not high enough to damage the roll. However, when cold edges, cold spots, and cobbles are taken into account it is easy to imagine that this stress could be much higher.

Figure 13 shows a section of the roll normal to the direction of rolling. This figure shows the stresses in the roll at the edge of strip. Here again the maximum radial tension of 400 psi must be considered as being greatly increased by the passage of cold steel and cobbles through the mill.

In addition to these localized tension stresses at points of contact of roll and sheet, another tension stress occurs which is independent of the bending stresses. Everyone is familiar with the compression test of a cast iron or concrete compression specimen, where the specimen will sometimes crack parallel to the load. The same phenomenon can take place in a roll causing it to split longitudinal'y. This photoelastic analog was used to determine the magnitude of these stresses.

Figure 14 shows the isochromatics (lines of equal shear) and isoclinics (lines of same direction of principal stress) for the two models tested. The stresses in these models were analyzed using the shear inte-



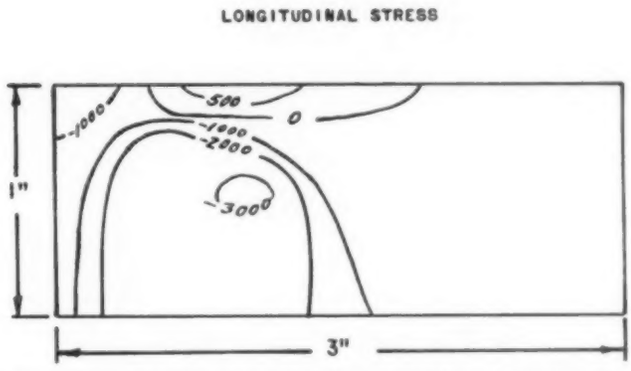
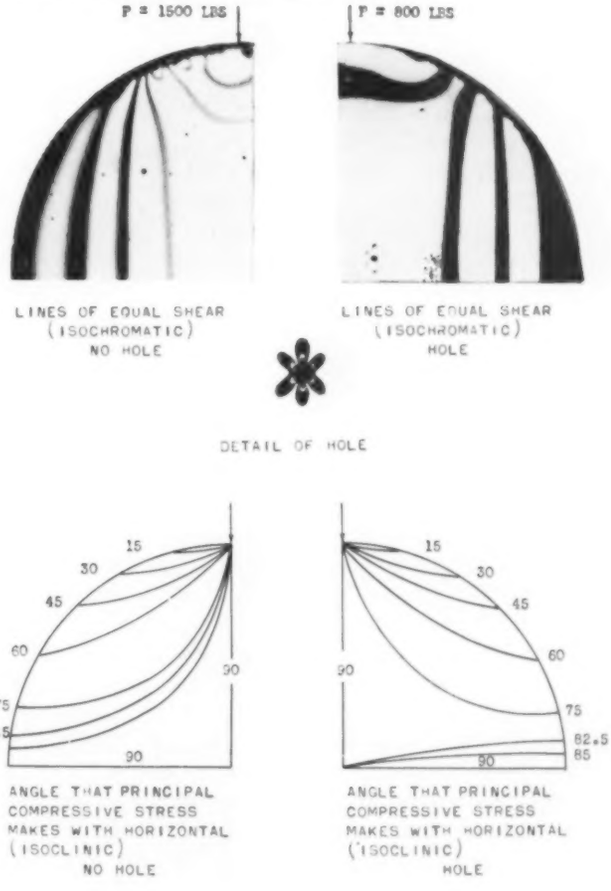


Figure 13 — Sketch shows local stresses in roll normal to direction of rolling at edge of strip.

Figure 14 — Photoelastic results are shown for a circular disc with and without a hole. Only one-fourth of the disc need be shown due to symmetry.



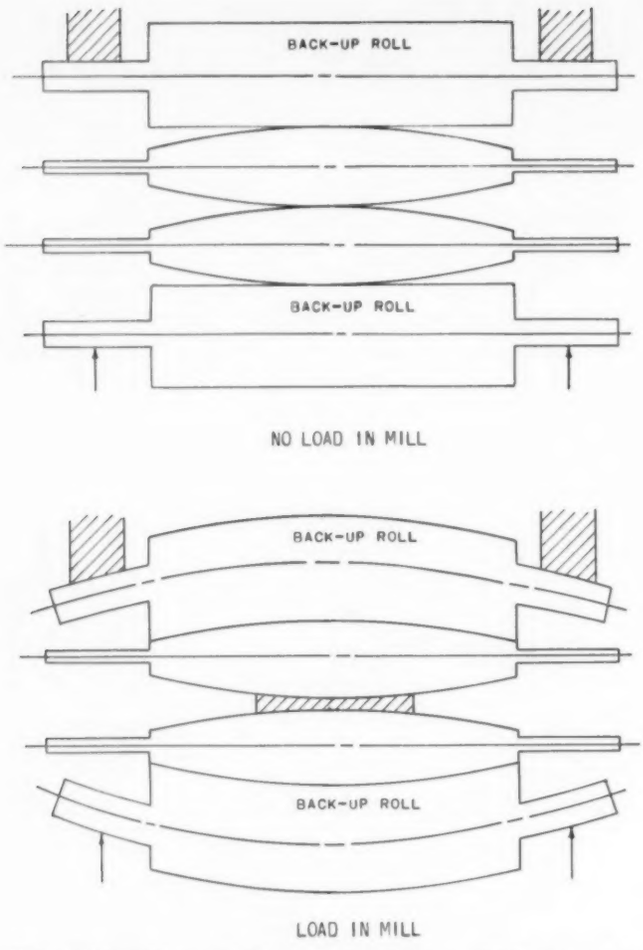


Figure 15 — Some of the roll deflections which occur are shown in this sketch.

gral.[2] The two models were chosen to illustrate the effect of a small hole on the stresses.

The analysis of the photoelastic data showed that for a 26-in. diameter solid cylinder with a load of 38,600 lb per in. of length, the principal stresses are 2,850 psi compression vertically and 250 psi tension horizontally. If a small axial hole is made in the center of the cylinder, the principal stresses at the hole become 4075 psi compression vertically and 1400 psi tension horizontally. The maximum tensile stress is increased by a factor of 5.6, from 250 psi to 1400 psi. This stress is too low to cause failure unless an overload is placed on the mill. In the event of an overload, the stresses could build up and cause fracture.

Bending Stresses—The bending stresses which can occur in a work roll cover a wide range. The work roll acts somewhat as a spline against the backup roll. Under rolling pressures the work roll deforms until it fits the contour of the deflected backup roll. If the work roll has the proper shape, that of the deflected shape of the backup roll, it will have no primary bending stress due to vertical loads only. Figure 15 illustrates such a roll. However, if the work roll is of any other shape than that of the deflected backup roll it will be distorted and therefore stressed. The amount of this distortion which is introduced into work rolls in common mill practice can be determined only after a more detailed study of the rolls being used.

The deflected shape of several backup rolls when rolling strip of varying width have been determined. The dimension of the rolls are given in Table I. These dimensions were taken from the drawings submitted to the Roll Breakage Committee by the steel companies. In our computations we have considered only the primary bending distortion. Shear distortion may be important in some of the shorter rolls and will be considered as we learn more about mill practice.

Figures 16, 17 and 18 show the center-line crown (difference in diameter between the end and middle sections of the roll body) which will just compensate for bending deflection of the backup roll and cause the work roll to just fit into the "pocket" formed in the distorted backup roll, Figure 15. If the work rolls are ground with this crown and are approximately parabolic in shape, as is common practice, there will be no primary vertical bending stress in the work rolls. To be sure there are still stresses in the rolls due to torsion and secondary effects, but this contouring of the roll will certainly help keep the stresses down.

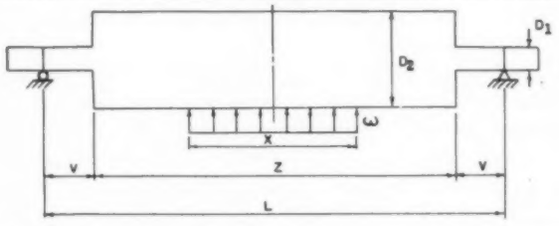
These crowns were computed for a "cold" roll; they must be adjusted to take care of the "puffing" or thermal expansion of the roll. Preliminary studies indicate that this puffing can be as high as 0.025 in. measured on the diameter. This will of course vary from mill to mill depending on the temperature of the roll.

SUMMARY

The temperature studies as summarized in Figure 8 clearly show that there is a critical time in the warm-up of a cold roll. If curves similar to Figure 8 were

TABLE I

Backup Roll Dimensions



CURVE	VARYING X IN	Z IN	L IN	V IN	D_1 IN	D_2 IN
1	12 TO 48	48.000	88.750	20.375	31.650	51.000
2	12 TO 43	43.000	76.500	16.750	24.443	45.375
3	12 TO 45	45.000	77.000	16.000	28.000	44.000
4	12 TO 55	55.000	87.000	16.000	27.085	45.000
5	12 TO 55	55.000	87.000	16.000	21.155	45.000
6	12 TO 40	40.000	59.250	9.625	17.300	33.000
7	12 TO 66	66.000	101.000	17.500	25.460	46.375
8	12 TO 68	68.000	103.000	17.500	25.290	46.500
9	12 TO 80	80.000	123.000	21.500	31.905	54.000
10	12 TO 75	75.000	108.000	16.500	29.998	49.500
11	12 TO 75	75.000	108.000	16.500	29.998	49.000
12	12 TO 77	77.000	108.000	15.500	25.989	49.000
13	12 TO 90	90.000	126.000	18.000	32.998	53.000
14	12 TO 90	90.000	134.500	22.250	32.250	53.500
15	12 TO 130	130.000	172.000	21.000	33.000	59.000

available to the mill operator for any particular roll, he could quickly tell when to slow down the mill and allow the heat to soak into the roll. By controlling operations carefully during the first 100 to 200 revolutions, perpendicular breaks in the body of the roll can be minimized.

Spalling is clearly accounted for by high radial stresses in the order of 16,000 psi set up in the roll by the temperature gradients. These stresses combined with the radial tension set up by the rolling pressures may be much greater than stresses accounted for by temperature gradients alone.

More study of the stresses caused by rolling pressures is needed. This study is dependent upon more data being made available from the mills. Preliminary plans have been made to obtain these data with the help of the committee. With additional basic data, we can determine more closely the stresses in the roll.

More information is also needed about the physical properties of the roll material. The material in the rolls as cast is of varying strength and stiffness (modulus of elasticity) at different distances from the surface. The Roll Manufacturers Institute is now obtaining coupons cut from different positions in the rolls. Upper limits may be placed on temperature stresses and allowable temperature gradients after data are available from tests of these coupons.

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DISCUSSION

PRESENTED BY

F. H. ALLISON, JR., Vice President, Rolls Div., Blaw Knox Co., Pittsburgh, Pa.

LOUIS MOSES, Mill Engineer, Bethlehem Steel Co., Bethlehem, Pa.

J. W. LUOMA, Manager of Metallurgy, Continental Foundry and Machine Co., East Chicago, Ind.

J. D. KELLER, Partner, Consulting Engineer, Associated Engineers, Pittsburgh, Pa.

M. D. STONE, Manager Development, United Engineering and Foundry Co., Pittsburgh, Pa.

CHARLES F. PECK, JR., Associate Professor, Department of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

FREDERIC T. MAVIS, Head, Department of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

Dr. F. H. Allison, Jr.: As a member of the Joint AISE and RMI Committee on Roll Failures, I would like to congratulate Dr. Peck and his associates on a very fine paper, and particularly, for again emphasizing the

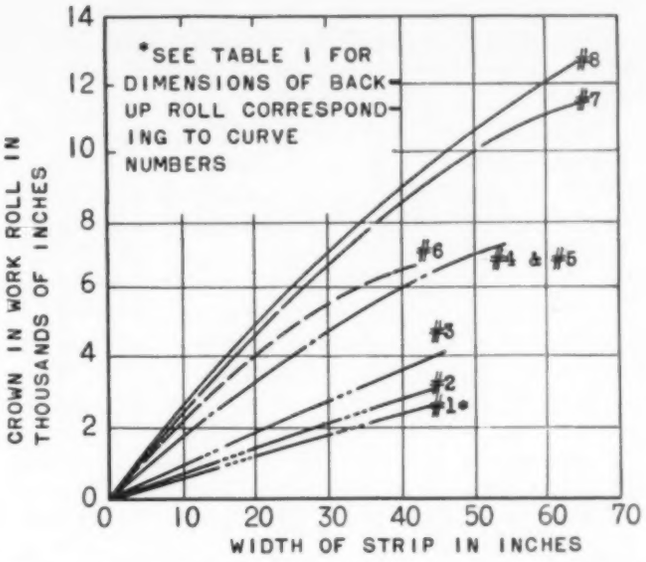


Figure 16 — Curves show practice of crowning on work rolls for eight different mills.

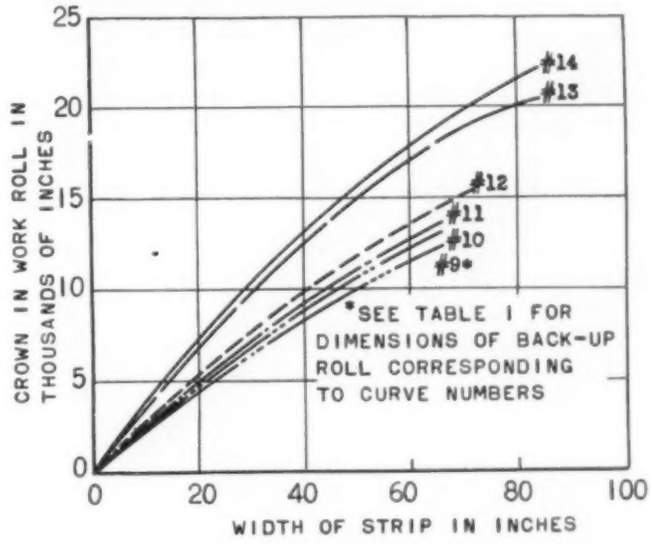
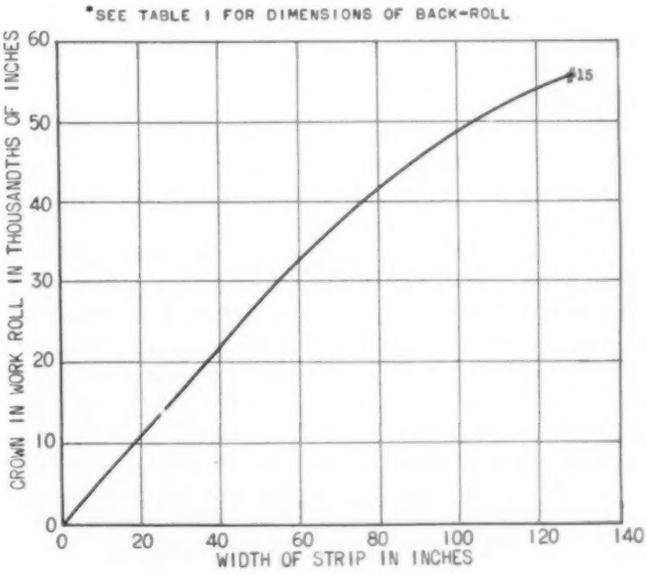


Figure 17 — Curves show practice of crowning on work rolls for six different mills.

Figure 18 — Curves show crown of work roll for a relatively wide mill.



very important part that heat plays in producing stresses which, added to the working stresses, may be likely to exceed the breaking strength of iron work rolls.

It should be pointed out that temperatures in itself will not produce these high stresses; but that it is the large differences in temperature that can occur within short distances in the roll metal that set up the breaking forces. An extreme example of producing these breaking forces is found in all our roll makers scrap yards where, oftentimes, large scrap roll sections cannot be broken to furnace charging size by the purely mechanical force produced by the drop ball. These same stubborn roll pieces, when notched with the high temperature acetylene torch and immediately followed by a stream of cold water will crack most satisfactorily; providing the tremendous power of thermal expansion and contraction which occurs with uneven heating and cooling.

The particular value of the present paper is that the author, with the generous help of the Bethlehem Steel Corp. at Sparrows Point, has been able to obtain actual figures for roll temperatures which allow him to calculate what appear to be very close approximations of the actual stress values in rolls originating from temperature differences.

Figure 8 shows that thermal stresses up to 24,000 psi can be induced in the roll metal at certain times during its heating up period. Now 24,000 psi, from temperature differences alone, is quite a large portion of the total 58,000 psi breaking resistance of the roll metal.

A most significant fact is that the maximum stresses from the heat effects are found below the roll surface at depths of ¾ to 1¾ in. Most of us who have had anything to do with the inspection of roll failures have been impressed with the many times that deep spalls have shown that the metal separation has seemed to start in this interior zone.

We will await Dr. Peck's further work with interest, where we hope he will be able to establish some actual values of the mechanical stresses induced in rolls during rolling. Such values, together with more accurate data of the tensile strength of the high nickel alloy iron metal, should allow us to calculate just about how much thermal abuse modern roll metals can withstand.

Louis Moses: The industry-wide survey of work rolls which is referred to in the paper shows greater total life, higher average run durations and more runs per roll when compared with previous years. The connotation of lessened breakage is confirmed by a narrower yearly comparison of certain individual mills as well as by general agreement among observers. Also noted is a reduction in the freakish breaks on which the causes have always been so puzzling. All of this is as it should be as the result of continuing experience, but it must not be forgotten that the improvement is accompanied by the factors of higher production rates as well as establishment of the current standards of quality surface, gage tolerances, etc. In no lessened measure, the survey reflects the improved roll-materials which the roll maker has evolved and the skill exhibited by mill personnel in handling the brittle rolls, the combination making the cited results possible.

Advances over current practices will be found to be just as involved and in some ways more difficult. The authors start from scratch in their study of roll-material properties, the roll maker will seize every means to further improve his rolls. The mills will unquestionably be faced with meeting augmented demands. This spells out that advances over current practices and recordings will be so much tougher to attain. It is obvious that a requisite accuracy of judgment at every turn demands the new tools which it is hoped this research project will provide.

Spallage accounts for some ten times the number of scrapped rolls when compared with fractured rolls. The analysis by Drs. Peck and Mavis which points to stress patterns creating cracks is noted in its relation to spallage. The formation of cracks as may be caused by temperature gradients coincide with the two extremes of expansion properties possessed by various roll metals. The harder the surface (demanded for run, durations, total life, etc.) the higher becomes the coefficient of expansion. In contrast, the closer the metal resembles grey iron, the lower the coefficient, which would lessen the hazards of cracking but negates the objectives. This defines one of the major problems facing the roll maker as well as challenging the user in his care of a more critical metal.

This clue that spallage and body breakage stems from the additional stresses of temperature gradients is highly interesting. Simply stated, a spall is caused by over stressed metal. Damaging spalls occur to steel backup rolls having much higher tensile strength and operating under very considerably smaller temperature gradients than work rolls. Spallage on cold-reducing mills is generally attributed to adhering metal on the strip increasing the gage as following a wreck or to multiple folds of a wrecked strip entering the roll gap. These considerations are not intended to becloud the clue, but some real problems must be solved before the actual origins of spallage are actually known. In favor of the authors' approach is the often observed presence of hair line cracks on work rolls. Such a crack is evidence of a released stress and if it is not objectionable, it may be that by so much a safer roll. Opposed to this the crack is a starting place from which a spall may start or even grow to a body-fracturing crack. The paper appears to show that a critical temperature occurs at some consistently or related radial depth which, combined with the working stresses, causes spallage. It will be interesting to know whether the maximum stresses induced by nearly point contacts of two loaded cylinders would lie in this same location.

J. W. Luoma: I wish to compliment Dr. Peck and his colleagues for a fine contribution on a subject that has been a bone of contention between roll makers and roll users for a period of several years.

There have been some papers published in the past on the possible causes of roll breakage. One of these causes has been attributed to extreme differences in temperature between various parts of the roll during some stage of the rolling operation.

Although these temperature conditions have been

generally recognized, I believe Dr. Peck's paper is the first one to show the actual temperatures which are built up, and the corresponding stresses which these temperatures create.

Dr. Allison has commented upon Figure 8 in Dr. Peck's report which shows the longitudinal temperature stresses which may be generated in the sub surface layers of an early stand finishing work roll after certain numbers of revolutions. This figure indicates that an extreme surface temperature gradient is set up when the hot strip makes initial contact with the "cold" roll to create an almost instantaneous compressive stress of 22,000 psi at the ¼-in. subsurface depth.

Would preheating of the roll prior to installation in the mill help to alleviate this sharp temperature gradient, and minimize the resultant sudden shock at the contact area? If the stresses could be reduced during the very early stages of rolling, then premature spalling or breakage would be minimized also. Maybe the mill operators can supply an answer to the degree of preheating that can be safely applied to a newly installed roll. Naturally, there is a maximum limit to the degree of preheating, because the action of the coolants on a roll which might be too hot would cause it to split, as illustrated in Figure 10 of Dr. Peck's report.

Mr. Moses wondered whether there were other factors which might cause spalling, besides temperature gradients. I believe that the University of Illinois Engineering Experiment Station publications, one by H. R. Thomas and V. A. Hoersch, "Stresses Due to the Pressure of one Elastic Solid upon Another," University of Illinois Engineering Experiment Station Bulletin No. 212, 1930, and another by Eugene I. Radzimovsky, "Stress Distribution and Strength Condition of Two Rolling Cylinders Pressed Together." University of Illinois Engineering Experiment Station Bulletin No. 408, 1953, show that rolling pressures also play a part in the surface spalling of rolls. These authors have studied the stresses which occur when two elastic bodies or cylinders are subjected to contact pressures.

According to my interpretation, the perpendicular surface forces working on the contact area are converted into shear components at certain critical subsurface depths. These depths are predetermined by the diameters of the contacting bodies, the pressures applied, and the elastic constants of the materials in contact.

It is conceivable that an excessive momentary overload of roll surface pressure could simultaneously increase the subsurface shear stress to a value where incipient yielding or cracking could occur at some location in the critical subsurface layer. Under continued cycles of rolling stresses, this highly stressed or cracked location would be subject to early fatigue failure. Any initial small checks would grow larger and progress to the surface at a 45 degree angle, resulting in an ultimate surface spall.

It is also possible to develop spalling troubles when normal rolling pressures are used, and no accidental over loads are encountered. Under these favorable conditions, spalling can be induced by using a roll at a constant diameter for prolonged periods of service.

With a constant diameter and normal loading, the shear stress built up in the subsurface layers of a roll will tend to become localized in a circumferential plane, at a certain dictated depth. Repeated cycles of rolling with this fixed set up will eventually cause fatigue failure to occur in this region where the shear stress remains concentrated. Fatigue cracks produced in this manner will progress to the surface in the typical form of spalls. A plausible remedy for this type of spalling is to dress the roll surfaces at more frequent intervals. This reconditioning tends to remove work hardened surface layers, and automatically shifts the prior plane of maximum shear to a new, subsurface circumferential layer.

The periodic shifting of the shear stress to different layers in the roll, by means of surface dressings, helps to combat the cyclic fatigue which is apt to occur when this stress is permitted to remain localized for long rolling cycles.

I feel that Dr. Peck could spend some time on this phase of roll failure during his research studies for the coming year. I believe that he could do a worthwhile job on this problem.

J. D. Keller: It is an ungrateful task to point out some of the shortcomings of this otherwise excellent paper, which is in the nature of a progress report; but such criticism may be helpful to the authors in continuing their work on the subject of roll breakage.

With reference to the stresses caused by rolling forces, it seems to have been forgotten that such stresses also exist at the contact of the work roll with the backup roll, and are much greater in magnitude than at the contact of the work roll with the strip; though the temperature stresses at the former place are very much lower. With a work roll diameter of 26-in. and a rolling force or separating force of 38,600 lb per in. length as assumed in the paper, if E is 20,000,000 psi then the maximum compressive stress in the region of elastic contact of work roll with backup roll is 125,000 psi, or about 3 times the 42,000 psi maximum, shown in Figure 12 for the contact of the work roll with the strip.

In Figure 12 and the part of the paper relating to it, while compressive and tensile stresses have been shown, nothing has been said as to the Belaieff shear stress which reaches a very high maximum, not at the roll surface but within the roll material at a depth below the surface of about 30 per cent of the contact length. This shear stress is thought to be the cause of the "dinner plate" type of spalling which gave so much trouble in cold strip mills some years ago. See paper by N. M. Belaieff, publication in a Russian magazine in 1924, and see Thomas and Hoersch, Univ. Illinois Eng. Expt. Sta. Bull No. 212 (1930.)

Figure 11, though diagrammatic only, is believed to be misleading, if the ordinates are intended to represent stresses as stated in the text. While the absence of lateral restraint at the edges would reduce somewhat the pressure of strip on roll as compared to the middle of the contact width, this edge pressure would not become zero even if the strip were fully plastic and at the same temperature as the middle.

The authors have recognized that the edges and the strip ends are colder than the middle parts, and that

the pressures and stresses are correspondingly increased at those places, but they may not have realized the possible magnitude of such increase. At the lower temperatures, the strip material is partly elastic as well as plastic, and the action of the strip edge may perhaps approach part way toward that of a rigid punch, which has a stress magnification at the edges (in fully elastic material) of about 2½. See J. D. Keller, Steel, May 14, 1951, Figure 20. It is well known that cold "tails" on the strip can, as a result of this magnification, actually mark the roll surface, leaving a slight permanent indentation.

Referring to Figure 14, the authors seem not to be aware that theoretical solutions exist for both the circular section without a hole and the one with a small central hole. However, it is good to have the photoelastic determinations. For the section without a hole, Hertz first derived the equations, and Foppl clarified them so that from them, the compressive stress at the axis can be calculated as three times the average compressive stress, while the tensile stress at right angles to this is numerically equal to this average stress. For roll diameter and load as in Figure 14, the theoretical compressive stress at center $= (3P/\pi\, a)\, L = 1420$ psi (compared with 2850 photoelastically determined) and the tensile stress there is ⅓ of 1420 or 473 psi, (compared with 250.)

The magnification factor of 5.6, given in the paper as determined photoelastically for the stress at the edge of the hole, seemed high, but by combining Timoshenko's results with Foppl's, the theoretical magnification was found to be 6, which is an excellent check. However, the theoretical maximum tensile stress at the edge of a small central hole now becomes 2840 psi, or double the 1400 psi determined photoelastically. See S. Timoshenko, "Strength of Materials," (Van Nostrand, 1941), Vol. II, p. 316.

As to the temperature stresses, the only surprise is that they are not actually higher than shown in Figures 5 and 6. Even so, these very high compressive stresses not only are accompanied, near the edges of the strip, by very high shear stresses which could start cracks at an angle to the surface, but (probably more important) the compressive stresses themselves can cause heat-checking. The mechanism is this: The surface layers, under strong compression and unable to escape tangentially or longitudinally, relieve themselves by elongating plastically in the radial direction, taking a slight permanent set, so that now the unstressed form of a small element that had originally been a cube, becomes a rectangular prism of a length in the radial direction greater, and in the other two directions less, than the side of the original cube. Then when the surface layers are cooled, the adjacent inner layers prevent their contracting axially or tangentially, and the tensile forces necessary to hold them stretched to their original length in these directions become greater than the tensile strength of the roll material; and they crack both longitudinally and tangentially at right angles to the surface.

The writer has seen many blooming mill rolls with checkerboard cracks all over their surface; the wonder is, not that they break, but that they hold together at all. Of course, blooming mill rolls are not cast iron but steel; still, since they usually have 0.80 to 0.90 per cent C, their brittle characteristics are not too far from those of cast iron rolls. Although the authors state that the roll material which they tested had no ductility, this cannot be strictly correct; the material must be capable of taking at least some permanent set, even if very slight.

In the writer's view, roll fractures can be divided into two groups, namely:

1. Those attributable to accidents of operation.

2. Those due to deviations of the strength of individual rolls from the average. As to the first, one of the most important parts of the present paper is the noting of the fracture of the roll shown in Figure 10, and of the cause thereof. This is by no means an isolated case, and accidents of other kinds also are by no means rare. The superintendent of one of the high speed cold strip mills stated to the writer that practically every spalled roll, when its history was traced, was found to have undergone at some previous time a severe wreck when rolling.

Referring to the second group, the main point to note, which is usually overlooked, is that most rolls do not break—it is only the exceptions that do so. As the authors' results show, any combination of temperature stresses and mechanical stresses that is likely to exist, is not high enough to break a roll of average strength. There is one possible important exception to this statement, namely the effect of residual or shrinkage stresses "locked in" the rolls as manufactured. On this, our knowledge is lamentably meagre, and it is understood that an investigation of shrinkage stresses is on the authors' program for the near future.

Nevertheless, as regards roll breakages of the second group, it is generally true that their incidence is of a statistical nature, in accordance with modern views of physics. While the laws of nature were formerly supposed to be rigid and single-valued, most of them are now thought to be no more than statistical averages on a microscopic scale of a multitude of random microscopic or submicroscopic events. These fractures then represent the deviations or divergences from a statistical average. The study of fractures from this standpoint has been done mostly (to give the devil his due) by the Russians, who are nothing if not realists in all but their political theory. Starting with an idea not original with them, they did really excellent work on the relationship between the size of the fractured object and proneness to brittle fracture. This called for a statistical study of the probability of occurrence of internal flaws or cracks as related to the ratio of size of object to average size of such cracks.

The foregoing does not mean, however, that the causes or mechanisms of fracture are unimportant; on the contrary, they call for even more thorough investigation. Brittle fracture is by no means limited to materials such as cast iron or very hard steel; it occurs fairly frequently even in soft, normally ductile steel, as in the numerous brittle fractures of ships' plates during the last war, as well as occasionally in service pipes carrying gas into residences. To be sure, such fractures usually occur only at low temperatures, but are not limited to these.

The strength which solid materials should have,

based on the attractive forces between their molecules, is calculated to be 100 to 1000 times as great as the strength they actually have. Why the difference? The answer seems to be, because of cracks or dislocations between or even within their crystals. In the elastic range, the stress magnification at the edge of a crack may be as high as 10; at higher stress, in ductile materials it is relieved by plastic flow at the edge of the crack, but in hard materials of low ductility, this relief cannot occur.

A plausible attempt, not new, to explain the mechanism of fracture, is the Griffith theory. See A. A. Griffith, Phil. Trans. Roy. Soc., Vol. 221, A (1921), p 163-198. Cracks or flaws are always present inside any material, and brittle fracture occurs by the joining of these cracks. According to this theory, if the cracks are smaller than a certain critical size, brittle fracture is not propagated through the mass of the material. If a crack by any means is enlarged until the decrease of strain energy due to lengthening of the cracks exceeds the increase of free energy due to formation of a new (or enlarged) interface, then the crack becomes self-propogating through the material.

But there is a time effect also, resulting in what is called delayed fracture. This was first observed in glass, where a stress that did not cause failure if applied only for a short period of time, did cause brittle fracture if allowed to act over a longer period. The time effect is thought to be due to thermal diffusion of molecules, and to be accentuated by thermal fluctuations and corresponding stress fluctuations in small volumes of the material.

The time effect may also be explained in some cases by the prying apart of the sides of the crack by the building-up of occluded hydrogen in the vee at the edges of the crack; the hydrogen diffuses toward and concentrates at dislocations in the crystal lattice. Not only atomic hydrogen, as formerly assumed, but even molecular hydrogen can do this. An excellent study by W. A. Bell and A. H. Sully, Jl. Iron & Steel Inst. (British), vol. 178, Pt. 1, Sept. 1954, pp 15-18, of this phenomenon as it occurs in hard steel, has very important implications in the wider field of brittle fractures in general, and would even seem to tie in with the recent finding as to the overwhelming importance of hydrogen as effecting the strength of titanium and its alloys.

In cast iron rolls, the extremely heterogeneous character of the material gives chances for still other stress-concentration effects. Altogether, it can be said that the study of the causes of roll fractures has hardly more than begun.

M. D. Stone: The type of work that Dr. Peck is doing is the kind of work that the AISE should be supporting. The more of this we do, the more we will learn about what goes on in our mills, our rolls, etc.

The paper used a figure of 1500 F as the maximum surface temperature of the roll when rolling 1800 F strip. The temperature of the roll just before it came in contact with the strip was 230 F. Now, if you took two blocks of steel of equal size, one heated to 1800 F and one heated to 230 F and those are suddenly brought together, the surface temperature would change very rapidly.

Now, if the hotter block were much thinner or much smaller in volume than the other one, the average temperature would be less than the average of the two temperature readings. I am therefore wondering how you obtained the 1500 F.

A second point concerns the figures you give for the crowns. I believe your figure showed the strip to be thicker on the edges than in the center. I believe you could amend your picture to show the thickness of the material being rolled as essentially uniform. In that case the crown and bending of the rolls can be precalculated.

Charles F. Peck, Jr., and F. T. Mavis: We wish to thank the members of the Joint Committee of the Association of Iron and Steel Engineers and Roll Manufacturers Institute and the other engineers who have studied our report and offered their comments. Since this is a report on work still in progress the comments will guide us in piloting the future work.

Mr. Luoma has asked whether preheating of rolls prior to installation in the mill would help to alleviate the sharp temperature gradient and accompanying shock. We think so, but we do not have pertinent mill data. We understand that rolls are preheated in some mill operations.

Mr. Luoma's suggestion that spalling can be induced at normal rolling pressures by using a roll at constant diameter for long periods of service is also referred to by Mr. Keller. As Mr. Keller points out, the pressures at the backup roll are much greater than those at the strip. Corresponding stresses have been studied and they will be summarized in a later report. While we determined principal stresses—and therefore maximum shearing stresses from differences in principal stresses—we reported the maximum tensile stress because it seemed to be most important in brittle cast iron rolls. In steel rolls the shear stress might control.

A correlation of spalling and the frequency of roll surface dressings, following Mr. Luoma's suggestion, might be of considerable interest and it might lead to a clearer understanding of some causes of roll failure.

Figure 11 may not convey fully what we intended, judging by Mr. Keller's questions. The dotted surface aims to show schematically the deformed shape of the body—not stress.

Mathematical analyses of stresses in cylinders assume "line load" and unrealistic stresses near points of contact. The photoelastic model was loaded along a small saddle. It is worth noting that while the magnitude of the stress was less than mathematical in the model, the stress concentration factor remained about the same—namely 5.6 to 6. Our purpose in making the model was to check the stress concentration factor.

Dr. Stone seems to have answered his question about heat flow between a hot and a cold body when he used the word average. While the average temperature of the roll remains low, a very thin surface film becomes hot—giving rise to a temperature differential in the roll itself. Dr. Stone's second point concerning crown figures is well taken. However, if the work roll does not deflect, all the crown would have to be in the backup roll. Accordingly, the unstressed roll would be a cylinder and the strip would then be flat. Conceivably this could lead to other complications, such as poor tracking of the strip.

Application of Control Regulators to Steel Operations

. . . . in its place the magnetic amplifier is a very useful device . . . . one place where it finds effective use is as a small preamplifier . . . . for excitation of large machines, cost and simplicity of the system must be carefully evaluated and the degree of negative excitation required must be carefully considered . . . . for optimum results, all other components besides the regulator must be carefully selected and coordinated into the drive system . . . .

"MAGNETIC AMPLIFIER FOR INDUSTRIAL CONTROL SYSTEMS"

By R. G. BEADLE
Application Engineer
General Electric Co.
Schenectady, N. Y.

▲ IN recent years, there has been considerable interest in the static magnetic amplifier. Many articles have been written describing magnetic amplifiers and their applications. Many of these articles illustrate the advantages of the magnetic amplifier, but do not cover the limitations of the device or indicate what might be a reasonable scope of applications.

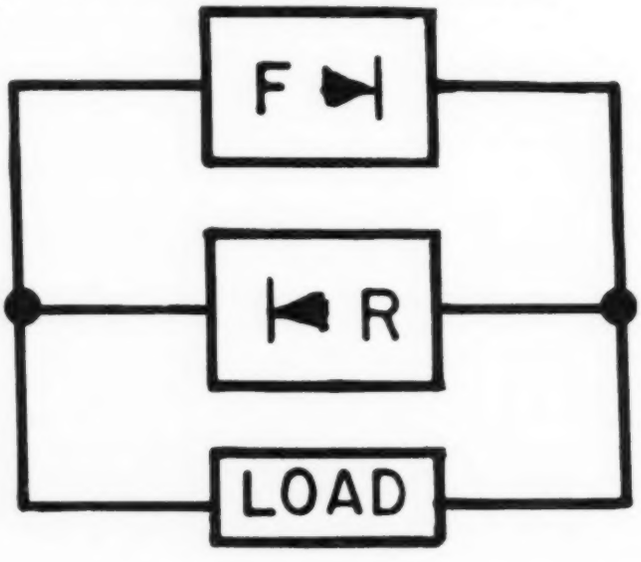
ADVANTAGES

The question naturally arises, "Why not use the magnetic amplifier in every application?" It is true that the magnetic amplifier has certain advantages over the rotating amplifier. The two major advantages of the magnetic amplifier are that it is static and panel mounted. These two features, are important from the maintenance standpoint. Since the magnetic amplifier is static, no attention need be given to bearings or brushes. Since the device is panel mounted by the electrical manufacturer, the user need not furnish conduit and wiring or a concrete base for a motor-generator set as in the case of a rotating amplifier.

LIMITATIONS

To go back to the question of using the magnetic amplifier for every application consider some of the characteristics of the device which often make it difficult to use them in regulating circuits. The most important of these characteristics is its uni-directional output. That is, the output polarity cannot be reversed. This, of course, is different from a rotating amplifier in which the output is reversed simply by reversing the field excitation. This is the main characteristic of the magnetic amplifier which makes it difficult to apply when the output must reverse.

Figure 1 — Because a magnetic amplifier cannot block normal current flow, this circuit will not work.



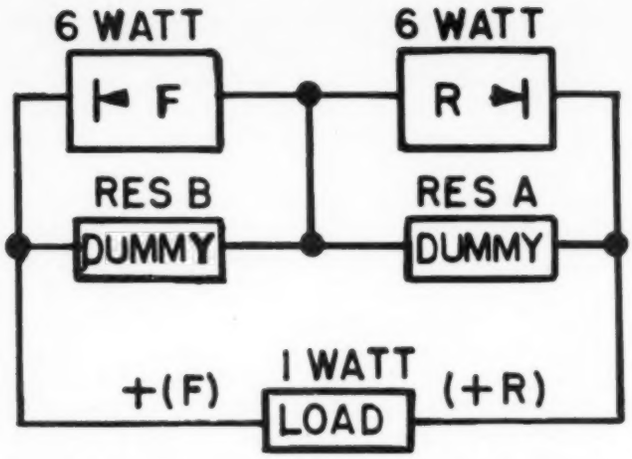


Figure 2— In the circuit both a forward and reverse amplifier are used.

Related to this characteristic is the fact that a magnetic amplifier will not block current in the normal direction of flow. If it could, the very convenient circuit of Figure 1 could be used for supplying a reversing load. Here a simple box with a rectifier is used as the shorthand symbol for a magnetic amplifier. This circuit shows a forward amplifier supplying plus voltage to the load and reverse amplifier supplying negative voltage to the load. However, because of the magnetic amplifier's inability to block normal current flow, this circuit will not work. If the forward amplifier is turned on, the reverse amplifier short circuits the load and vice versa.

Other poor characteristics which make the magnetic amplifier difficult to apply are briefly:

1. Output voltage varies with the a-c supply voltage.
2. A bias signal is required since with no signal applied, the amplifier is turned on.
3. The poor output wave shape of the device makes limit circuits difficult to use.
4. The poor wave shape makes the use of frequency sensitive feedbacks for stabilization difficult to use.

REVERSING CIRCUITS

To get back to the point of ability to produce negative voltage, since it has been stated that this is the major disadvantage of a magnetic amplifier, the question should be considered further. When is a regulator required to produce a negative voltage?

A regulator for a reversing adjustable voltage drive must produce both polarities since the excitation of the generator field must reverse to reverse the drive. A regulator for a non-reversing adjustable voltage drive must usually reverse to some extent. If the drive must decelerate rapidly, the generator field voltage must be forced negative to force the generator voltage down rapidly. Even to suicide the generator voltage, the regulator must produce a negative voltage to overcome the generator residual. Thus, there are a large number of drives which require the regulator to produce negative voltage. For this reason, let us consider the magnetic amplifier circuits which are available which allow a reversing output.

If the reversing is to be done on one load, the circuit of Figure 2 may be used. Here two amplifiers are used, a forward and a reverse, which produce a voltage on the resistors A and B. If the two amplifiers are producing the same output, no net voltage appears at the load. However, if the forward amplifier is turned on and the reverse amplifier is turned off, a forward voltage appears at the load. It is important to note that the installed amplifier capacity is 12 times that required by the load since considerable power is consumed in resistors A and B. Thus, with this circuit, the magnetic amplifiers have 12 times the rating of an equivalent rotating amplifier.

If the load can be split into a buck and a boost field of a generator or exciter, the circuit shown in Figure 3

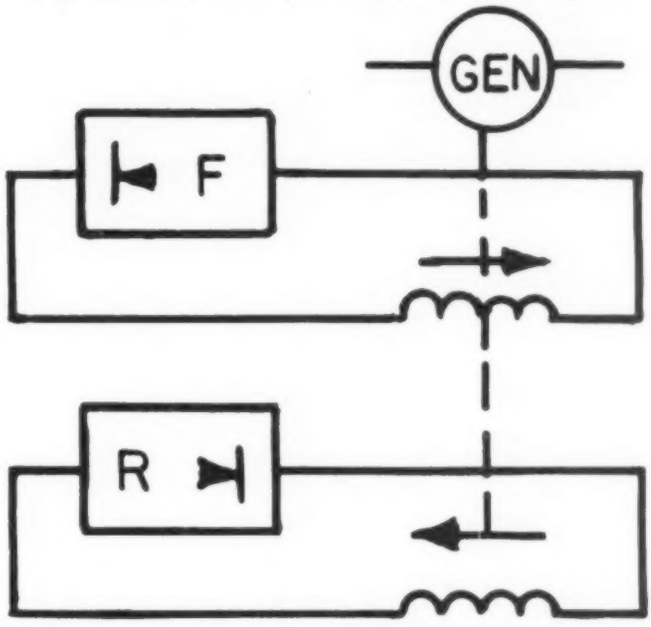


Figure 3 — This circuit requires two magnetic amplifiers, each of which have a power output equal to the excitation requirements of the generator.

can be used. Here again two amplifiers are used, one attempting to produce positive generator voltage and the other negative voltage. If the two amplifiers are producing equal outputs, the generator voltage is zero. If the forward unit is turned on and the reverse unit turned off, the net excitation will produce a positive voltage in the generator. This circuit requires two magnetic amplifiers which each have a power output at least as great as the excitation requirements of the generator. Thus, with this circuit, the installed capacity in magnetic amplifiers must be considerably greater than an equivalent rotating amplifier.

An important point, is: if the negative excitation requirements are small or of short duration, the two circuits just discussed can be unbalanced so they become much more efficient. This is the case with most non-reversing adjustable voltage drives. To design these modified push-pull circuits, we must determine the amount of negative excitation required.

APPLICATIONS

With this brief summary of the advantages and disadvantages of the magnetic amplifier, let us consider the field of application of the magnetic amplifier.

The advantages, of course, make it desirable to use the magnetic amplifier in place of other devices, but at the same time, truthful consideration must be given to the disadvantages or shortcomings of the magnetic amplifier. The importance of these shortcomings depends upon the application. For some applications, the disadvantages listed earlier may not apply. In like manner, other applications may require such a considerable sacrifice of performance, economy, or simplicity, that the advantages of using the magentic amplifier are lost. In between these extremes, of course, lies the problem for it must be decided for each case if the gains justify the sacrifices.

In the following section, the possible applications of magnetic amplifiers have been divided into four types. These applications are evaluated with regard to the suitability of magnetic amplifiers.

Preamplifiers—When the magnetic amplifier is used as a preamplifier there are many circuits which may be used since high efficiency is not important. A preamplifier is not always necessary but becomes desirable when the gain of the regulator must be increased, when time constants must be decreased or when impedence must be better matched. The magnetic amplifier is relatively simple to apply in a system when it is to be used as a preamplifier, since most of its limitations pose no problem. The major disadvantage of a magnetic amplifier (uni-directional output) is overcome by using two units in a buck-boost connection on two exciter fields. Since such preamplifier units are small, this is feasible. The use of two units does not represent a great cost.

There are so many applications in which the magnetic amplifier might be used as a preamplifier that it is impossible to make a comprehensive listing. However, some examples to illustrate its use may make the type of application clearer.

1. The magnetic amplifier preamplifier may be used to provide gain and increase the input impedence of a voltage regulator. Such a system had been successfully used in a reversing planer drive which was to be controlled from a pendant station. To make it possible to use small potentiometers for control, a magnetic amplifier was necessary to preamplify the small signals.
2. The magnetic amplifier has often been used to amplify current limit signals so that current may be more accurately limited. A magnetic amplifier was recently employed in this manner on a 12,000-hp blooming mill. It proved highly successful and allowed rapid top speed reversals since the pump-back current was accurately controlled.
3. The magnetic amplifier has been used to amplify an inertia compensation signal for the tension reel of a high speed cold strip mill. To obtain a voltage proportional to acceleration, a transformer is connected across a speed pilot; the output voltage of the transformer, which is proportional to rate of change of speed, is amplified by means of the magnetic amplifier and applied so as to influence the regulator.
4. Other uses of such a preamplifier are to amplify stabilizing signals, or to operate relays from a small signal.

Limited Range Regulators—Some voltage regulators serve to maintain a constant voltage while compensating for disturbances of load and speed, but are not required to regulate the voltage over a wide range. If size permits, a magnetic amplifier is easily utilized in a system of this type, since the regulator need not reverse. That is, the generator field current or field voltage need not reverse since the generator operates over a limited range.

In this category falls the most frequent application of magnetic amplifiers; voltage regulators to regulate the a-c voltage of engine driven alternators for aircraft, railway equipment, etc. The magnetic amplifier ideally serves this application. Other applications of this nature are the excitation of induction heating generators and the excitation of the phase shifting network for power rectifiers. In this same category is a d-c motor field current regulator. Such applications are well suited to the characteristics of the magnetic amplifier, since here again, the motor field excitation need not reverse. Thus, only one magnetic amplifier need be used.

One example of this type of application is a cold strip mill in which it is desired to have a means of quickly changing the motor field current at the operator's command. Here the magnetic amplifier provides a convenient means to obtain speedy and accurate control of the motor field current. There are many applications of tension reels in which the magnetic amplifier has been used to regulate the motor field current as the reel builds up. Such drives are found in practically all continuous process industries, paper, rubber, plastics, textiles, steel, etc.

Non-reversing Adjustable Voltage Drives—The magnetic amplifier may be used to supply the field of the generator for a non-reversing drive. For this application, the cost of overcoming the "plugging" limitation of magnetic amplifiers must be weighed against the advantages brought about by their use. "How fast must the drive stop?" is the important question to be answered.

For example consider, say, a processing line using a 100-kw, 1200-rpm generator. This machine has a 1.5 second field time constant. If this drive is to be stopped in one time constant or 1.5 seconds, the regulator must produce a negative excitation of more than 60 per cent. However, if the drive is required to stop in three time constants or 4.5 seconds, the negative excitation requirements are not nearly so severe. A 4.5 second stop requires only about 10 per cent negative excitation.

Continuous steel mill processing line machines are small and are usually not capable of stopping the heavy coils in less than 5 seconds. The generator time constants are usually 1.5 seconds so magnetic amplifiers are reasonable for these applications. Conveyor lines for rubber, lumber, and steel are non-reversing with stopping times suitable for the use of magnetic amplifiers. The stopping time of paper machines is not critical. They would therefore, be good magnetic amplifier applications.

There are certain drives which have a high friction or work load so that dynamic braking may be used for fast stopping. For such a drive, a magnetic amplifier

may be used since it would not need to produce negative excitation.

Reversing Adjustable Voltage Drives — Since the generator field excitation must reverse, it is likely that only the smallest drives can economically use all magnetic amplifier regulators. However, such drives may advantageously use an exciter with a small magnetic amplifier as a preamplifier. Then the application would fall under the first category.

SUMMARY

The magnetic amplifier is another very useful device which the designer of drive systems may use. As small preamplifiers, the magnetic amplifier combines small size, fast response, and convenient characteristics and should be frequently used. When the magnetic amplifier must excite a large machine directly, the cost and simplicity of the system must be carefully evaluated. The important point to consider is the degree of negative excitation required.

DISCUSSION

PRESENTED BY

WILLIAM C. WHITE, Supervisor Electric Maintenance, Rotary Electric Steel Co., Detroit, Mich.

R. G. BEADLE, Application Engineer, General Electric Co., Schenectady, N. Y.

HARRY E. BOEDECKER, Superintendent Construction, Engineering Dept., Northeastern Steel Corp., Bridgeport, Conn.

HAROLD C. HOEFT, District Manager, Stran-Steel Corp., Oklahoma City, Oklahoma.

PAUL M. FISCHER, Electrical Engineer, Cutler-Hammer, Inc., Milwaukee, Wis.

William C. White: I would like to ask Mr. Beadle if he could give us some idea in the difference in response between the magnetic amplifier and the rotating amplifier.

R. G. Beadle: Perhaps the best method of discussing the response of a regulating device is by use of the term "figure of merit." Figure of merit is defined as the ratio of power gain to time constant. For a given device, the figure of merit is constant, so that although the time constant may be made smaller and smaller, the power gain also decreases.

In small ratings (say below 1 kw), the 60-cycle magnetic amplifier has a higher figure of merit than any rotating amplifier. In the larger sizes, the figure of merit of a 60-cycle magnetic amplifier is greater than that of a single stage rotating amplifier, but is less than a two stage rotating amplifier.

The figure of merit of a magnetic amplifier is proportional to the supply frequency. Due to this higher figure of merit, 400-cycle units have been used for some fast response regulating systems.

Harry E. Boedecker: I would like to ask, how may a drive incorporating a magnetic amplifier be protected against a-c voltage failure?

R. G. Beadle: It is important that an industrial drive be brought rapidly to a stop in case of failure of the a-c supply voltage. Most industrial drives have line contactors so that the drive may be rapidly stopped by dynamic braking.

However, there are certain types of drives such as power shovels or log carriage drives which, for safety of personnel, do not use line contactors. Thus, they must be regulated to a stop by regeneration. When a drive uses a rotating amplifier, this regulated stop can be accomplished since the amplifier continues to coast for some time after power is lost. Thus the machine can still be used for regulating purposes.

However, when a-c power is lost on a magnetic amplifier, the output voltage immediately disappears and the device can no longer be used for regulation. Thus, a regulated stop after loss of a-c power is difficult to accomplish with a magnetic amplifier drive.

If the drive uses a magnetic preamplifier and a rotating power amplifier, a regulated stop can be obtained by regulating directly on the rotating amplifier and omitting the magnetic amplifier from the regulating loop.

If an unregulated stop is satisfactory, the generator field could be shortened through a resistor or suicided on its own armature voltage.

Harold Hoeft: What does one have to do to maintain a control using magnetic amplifiers?

Paul Fischer: In our experience with maintaining magnetic amplifiers, we have had an occasional coil burn out, just as you would have if you put out a number of transformers. We have had some rectifiers to replace because of mechanical damage. However, in anticipation of difficulties, our magnetic amplifiers were provided with readily accessible screw terminals, so that if something should go wrong, they could very quickly be removed from the circuit and replaced. We have ammeters and voltmeters in critical portions of the circuit which will show up not only failures in the magnetic amplifiers, but also failures elsewhere in the regulated system.

One example was on the Fairless conveyor line. A motor bearing was running tight and began to bind. It showed up immediately on the output of the regulator because of the fact that the motor was getting to a point where it was overloading. At high currents, you could see the immediate departure from the normal running conditions. As the load increase came on, you could see this one amplifier working a lot harder than the rest. It was during the installation of the lines that we were able to locate the trouble.

R. G. Beadle: I understand you have an application of a magnetic amplifier for a blooming mill where you obtain reversing output with magnetic amplifiers. However, one thing that interests me is the fact that you require two one-hundred per cent shunt field windings in the generator. That is, a one-hundred per cent winding to produce a voltage in the forward direction and a one-hundred per cent winding for the negative direction.

In an old generator, how did you manage to get two one-hundred per cent windings? That is, it is surprising that there was physically enough winding space in a machine that was not originally designed for it. Could you say something about this?

Paul Fischer: That was a new rotating piece of equipment. It was a 5-kw exciter. It was built to our specifications, to match the magnetic amplifier which we intended to use. We will call it an exciter-exciter, because that is what it does. It excited the exciter; that was the old equipment which then worked in the two 2000-kw generators.

"EFFECT OF REGULATOR SYSTEMS ON ASSOCIATED APPARATUS"

By W. R. HARRIS

Manager, Industry Engineering Dept.

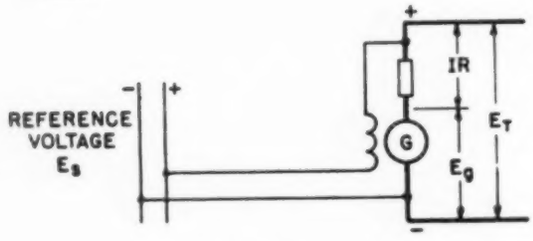
Westinghouse Electric Corp.

East Pittsburgh, Pa.

▲ PRESENT-DAY regulating systems control the operation of complex drives smoothly and with authority. This is the result of careful engineering and coordination of each component of a drive system including the regulating element, exciters, main drive generators and motors, to meet the requirements of the driven machine. The regulating element is the system boss but it must have a team of skilled workers to obtain the optimum performance it commands. To illustrate how the regulating element affects the specifications for associated apparatus, a study was made on the anacom computer to demonstrate the effect of such variables as system gain, exciter size and ceiling voltage, size of damping apparatus, effect of rotating machine time constants and saturation, and the effect of rising machine characteristics.

Figure 1 illustrates the effect of gain on the steady-state performance of the regulating system. The connections are for a simple single-delay system where the field of a d-c generator is connected between its own terminals and the reference voltage. The generator is then its own regulator. The system voltage gain "A" is defined as follows—if one volt on the generator field produces 50 volts at the generator terminals, the system gain would be 50 to 1. In the tabulation the full-load resistance drop in the generator has been taken as 10 volts for a generator rated at 100 volts output. The no-load terminal voltage of the generator is kept constant at 100 volts, and the voltage under full-load condition is shown for various values of gain.

Figure 1 — Effect of regulator system voltage gain on steady-state error with 10 per cent generator regulation.



$$E_T = E_g - IR$$

$$E_T = \frac{A}{1+A} E_s - \frac{IR}{1+A} \text{ STEADY STATE}$$

A = SYSTEM GAIN

A	E_f	E_T NO LOAD	E_T FULL LOAD	% ERROR
0	–	100	90.00	10.00
1	200	100	95.00	5.00
2	150	100	96.67	3.33
5	120	100	98.33	1.67
10	110	100	99.08	0.92
25	104	100	99.62	0.38
50	102	100	99.80	0.20
100	101	100	99.91	0.09

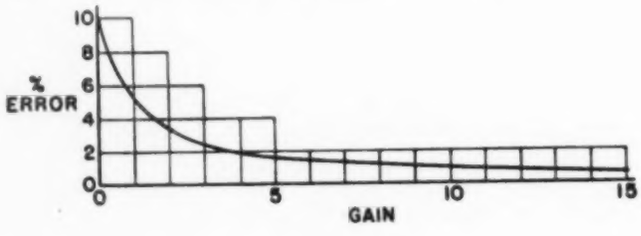


Figure 2 is a two-delay voltage regulating system utilizes a rotating regulator.

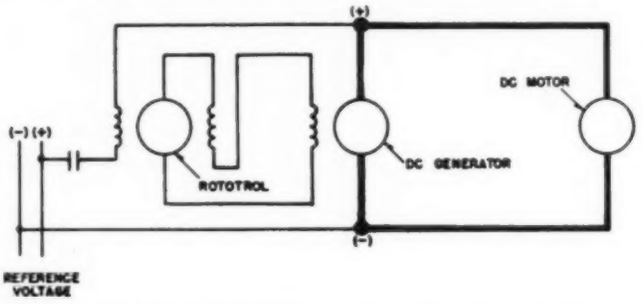


Figure 2 — Two-delay voltage regulating system utilizes a rotating regulator.

Such a single time delay system is ideal from a simplicity standpoint, but it is not practical because of low gain and high power drain on the reference circuit. For instance, assume that a 3000-kw generator rated 600 volts requires 3-kw of excitation. For a gain of 50, the field voltage would be 12 and the field current 250 amp. Since the reference bus must be at 600 volts, the drain from this source is 150-kw (250 amp x 600 volts). An amplifier or separate regulating device is invariably required to reduce the drain to reasonable values.

Figure 2 shows a two-delay system with a rotating regulator operating in the field of the direct-current generator. With this system the drain from the reference voltage source will be only a few watts compared with the 150-kw cited above. In general, the better the regulating element as to power amplification, the smaller the drain from the reference voltage, which is an important consideration in the size of pilot generators, exciters, and other reference and measuring circuits.

An anacom computer study was made on a two-delay system as shown in Figure 2 to demonstrate the effect of system parameters on regulated system performance. For this study the time constant of the regulator was taken as 0.1 second, the time constant of the generator as one second, the motor armature time constant 0.05 second, and the mechanical time constant of the motor and connected load 0.2 second. It should be again stressed that the regulator is merely one com-

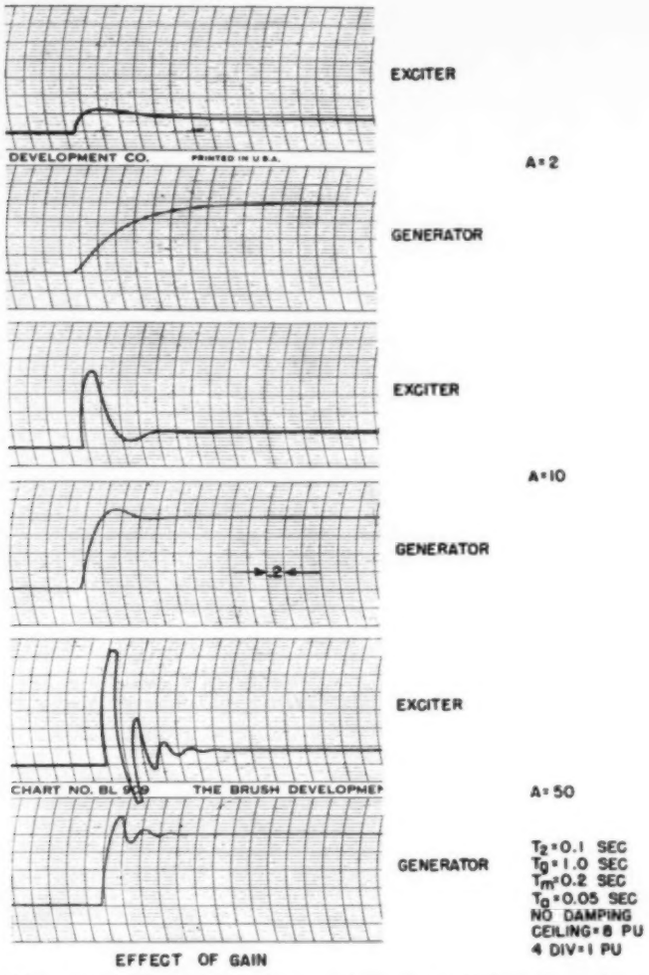


Figure 3 — Effect of system voltage gain "A" on transient response. The traces are exciter voltage and generator voltage against time.

ponent of the system. To obtain the best performance, good regulator design must be coupled with good motor and generator characteristics and good control, as will be shown.

Figure 3 illustrates the effect of system gain on the transient response of the regulating system. In this case the contact applying the regulating field was closed which takes the generator voltage from zero to full-rated value. No damping is used. With the various gains the generator voltage response and the exciter ceiling voltages in per unit values are as follows:

Gain "A"	Transient response seconds	Per unit exciter voltage
2	2.50	1.5
10	0.25	5.2
50	0.10	8.0

System gain has a marked effect on transient response. Also, note how the ceiling voltage of the exciter is affected by system gain. The sluggish generator field has electrical inertia much the same as a heavy flywheel has mechanical inertia. It takes time to get electrical current in motion just as it takes time to accelerate an automobile. To obtain fast response, a high degree of forcing must be applied to sluggish fields. The ceiling voltage of the computer used for this study was a maximum of 8 per unit; otherwise with a system gain of 50, the exciter voltage would have been somewhat higher than 8 times rating and the response would have been somewhat faster.

Figure 4 illustrates the effect of a limited exciter ceiling voltage on regulating system performance. On this figure, as well as on Figure 3, no damping is applied, and it will be noted that the regulator is somewhat unstable at high values of gain. It is interesting to note that as the exciter ceiling is limited to 200 per cent with the gain and other constants remaining the same, the response changes from 0.1 to 0.6 second. Thus high peak exciter voltage, as well as high gain, is necessary to get fast transient response.

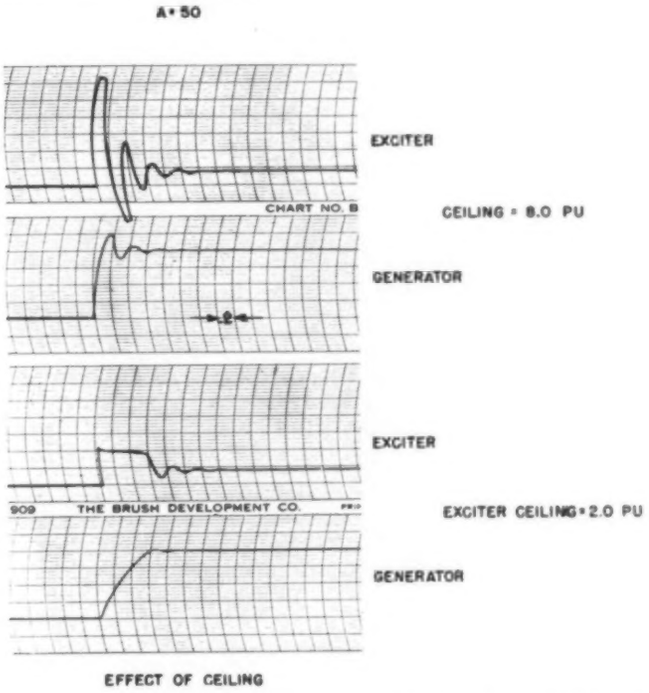


Figure 4 — Effect of exciter ceiling voltage on transient response with a gain of 50 and no damping. The response time of the generator voltage is much slower with low exciter ceiling.

Table I gives the steady-state kilowatts required by various machine fields and the equivalent exciter rating actually applied to force fast response. For the blooming mill generator voltage regulator, the exciter rating is in excess of ten times the steady-state field requirements. These values were taken from a recent 10,000-hp twin drive using four 2500-kw generators. The overall performance on reversal from base speed in one direction to base speed in the opposite direction was one second—the fastest that had been obtained to date.

On the blooming mill motor fields it is also necessary

TABLE I

Exciter Sizes for Regulating Systems

Mill	Regulated function	Steady-state field, kw	Exciter rating
Blooming	Generator voltage	10	104
Blooming	Motor field amps	45	280
Tandem cold	Generator voltage	1.8	7.5
Screwdown	Generator voltage	.7	10

to apply high forcing values in order to obtain fast response. The values in the chart are for the same drive as that cited previously—the exciter size is 280-kw for a steady-state field kw of 45. The values for the tandem cold mill voltage regulator and the variable voltage screw-down variable voltage regulator also reflect increased size to provide the necessary forcing values. Fast response can only be obtained at the expense of large exciter sizes. In fact, some of these "exciters" are so big that they are almost in the class of main generating equipment.

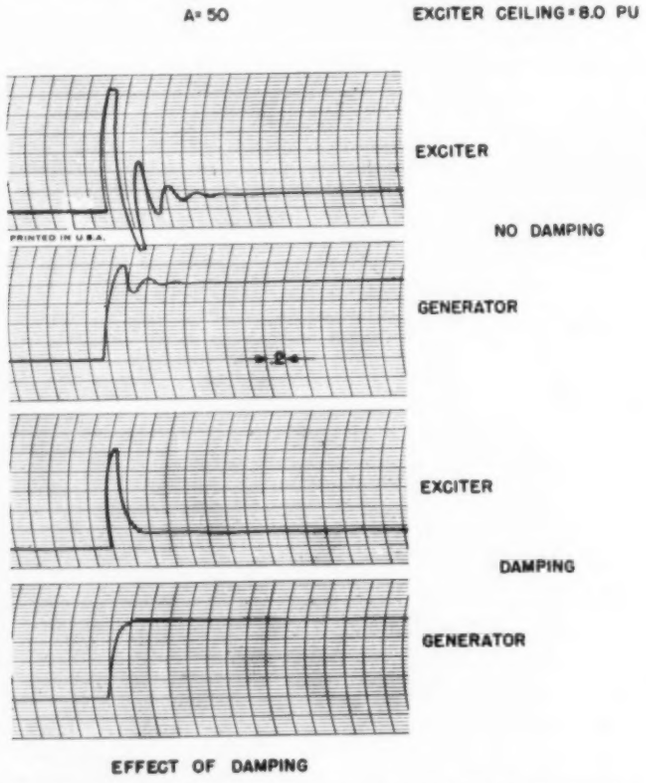


Figure 5 — Effect of damping on transient performance. Good damping is essential with modern regulating systems.

The performance shown on the foregoing figures was without any damping whatsoever. Figure 5 illustrates the performance with a gain of 50 without damping and with sufficient damping to get practically no overshoot. Without damping the system has an overshoot of 25 per cent and a decay of oscillation of about 75 per cent per cycle. The response from zero to rated voltage is about 0.1 second, and all oscillations disappear in approximately 0.8 second. Such performance cannot be tolerated in actual practice. However, with proper damping, rated voltage is reached in about ¼ second with negligible overshoot.

The size of the damping transformer (or other damping element) is proportional to the power level in the input circuits of the regulator. The higher the power level, the larger the damping transformer. Thus the regulating element design is highly important because of damping transformer or damping capacitor size. The new magnetic amplifier regulators are attractive from this standpoint, particularly the two-stage designs. The energy level in the control windings is so low that damping means of small size can be effectively utilized.

With two or more time delays, damping problems can become serious, depending on the relations of the time constants of the various elements. In general it is desirable to separate the time constants as widely as possible, and to have the lowest time constant in the regulating element. The wider the separation, the more inherently stable the system. The size of damping apparatus is materially affected by such considerations.

Figure 6 illustrates the effect of generator field time constant with the total gain and exciter time constant remaining the same. With a generator time constant of one second and fairly good damping, the response is about 0.3 second and the ceiling exciter voltage is 450 per cent. With a generator time constant of 3 seconds and appropriate change in damping, the response is about 0.95 second and the ceiling exciter voltage is about 520 per cent. The larger the generator, the longer the time constant. The large generators from 2000 to 4000 kw have time constants of from 3 to 5 seconds, whereas smaller machines 50 to 200 kw, such as those used for processing lines, have time constants of from

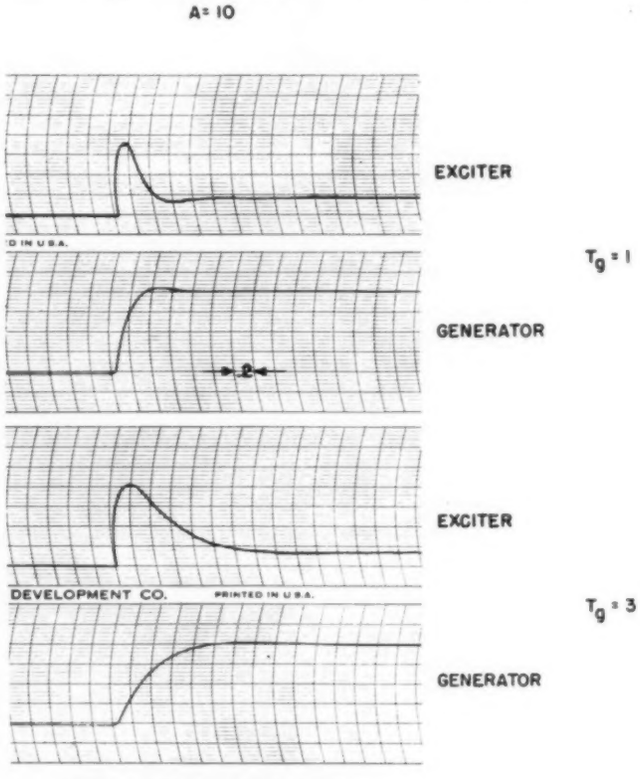


Figure 6 — Effect of generator field time constant on transient performance with gain remaining the same. The upper charts are for a generator time constant of one second, and the lower charts for a generator time constant of three seconds.

0.5 to 1.5 seconds. The larger the apparatus, the more the gain must be increased, and the more the exciter size must be increased, to obtain a specified response time.

The generator saturation has to be carefully watched on regulating systems requiring a close match with other systems, for example, the individual generator tandem cold reduction mill drives. Figure 7 illustrates the difference in response, first with no saturation, and second with the saturation slope ratio one-third

beginning at 75 per cent voltage. Close examination of these two curves will show that they are essentially the same up to 75 per cent voltage. Beyond this value the saturation in the generator cuts the total gain of the system to one-third of its former value, and the response is correspondingly slower. If an unsaturated and a saturated system were operated side by side as on an individual generator tandem cold reduction mill drive, the difference would be enough to cause a major change in strip tension as the mill is accelerated.

The difference cannot be reconciled by an increase in regulator gain. The performance at either the start or the end of acceleration could be matched, but it is impossible to match both conditions. On such drives it is necessary to match generator saturations within narrow limits to get the best mill performance. Generally, low values of saturation are used which increases the size and cost. For systems where the regulator operates in the motor field (reel drives and rod mill speed regulators), saturation must be carefully watched in order to get good performance over the entire speed range.

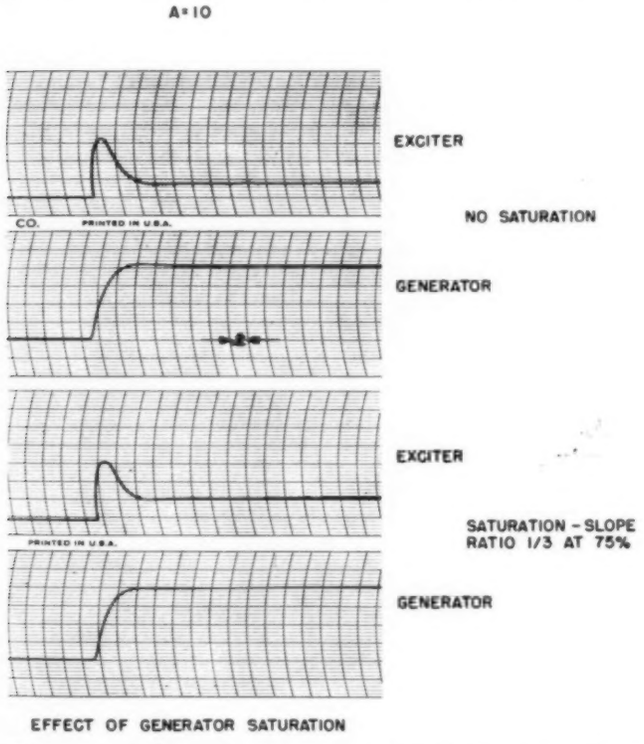


Figure 7 — Effect of generator saturation on transient response. Note higher steady-state exciter voltage on the lower chart with generator saturation.

For the above cases a generator voltage regulating system with normal drooping voltage-load characteristic on the generator has been discussed. A rising characteristic on the regulated machine can frequently cause serious difficulty, particularly if the system time delays are close to one another. For instance, with 0.1 and 1.0 second time delays, no instability was encountered even with a rise in generator voltage because of the wide separation of the time constants. Figure 8 shows the effect of lowering the generator time constant to 0.2 second which approaches the motor mechanical time constant of 0.2 second and the regulator time constant of 0.1 second. With 1⅔ per cent droop, the damping was adjusted to give essentially no overshoot. However, more oscillation will be noticed than on previous figures because the generator field time delay of 0.2 second is fairly close to the regulator time delay of 0.1 second. With a rising voltage load characteristic on the generator and all other system constants remaining the same, the performance begins to become critical and several oscillations are introduced. In general, the best performance is obtained when there is no rise in the speed load or voltage load characteristics of any of the motors or generators involved.

The trend in the steel industry has been toward

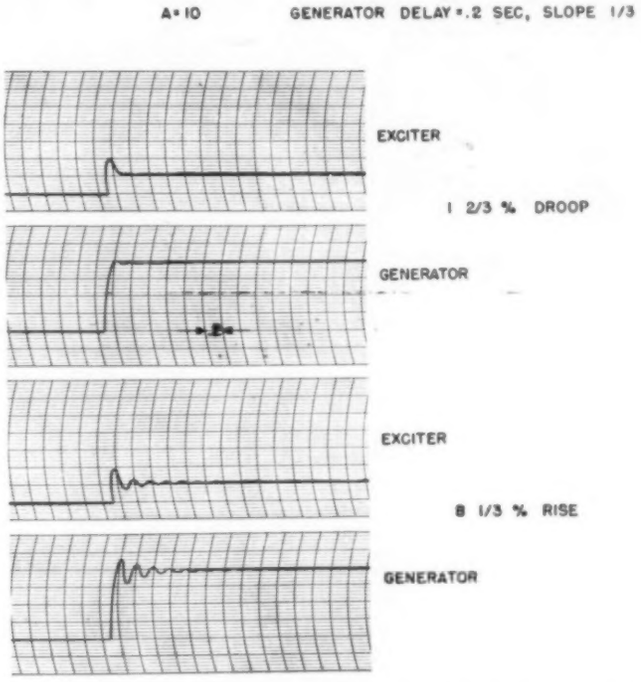


Figure 8 — Effect of rising voltage load characteristic with close system time delays.

faster operation, more continuous processes, and better drive and mill performance in order to improve tonnage and quality of product. These factors have led to the use of a large number of regulating systems for main and auxiliary drives. A good example is the 16,000-hp universal slabbing mill recently put into service at the Great Lakes Steel Corp. Figure 9 shows the 12,000-hp, double-armature twin drive for the horizontal rolls, the 4000-hp, 60-rpm motor for the vertical rolls, the flywheel motor-generator set, the auxiliary motor-generator sets, and other associated equipment. A total of 27 regulating systems are used to control the main drive, auxiliaries, and associated equipment on this mill. Six systems are in use on the main drive as follows:

1. Generator voltage control.
2. Motor field current control.
3. Load balance between the upper and lower horizontal roll drives.
4. Power input control of the wound rotor motor driving the flywheel set by control of the slip regulator.
5. The edger generator voltage control.
6. The edger motor field control.

Sixteen regulating systems are used for control of the auxiliary drives. These are all generator voltage control systems for control of the ingot buggy, tables, feed

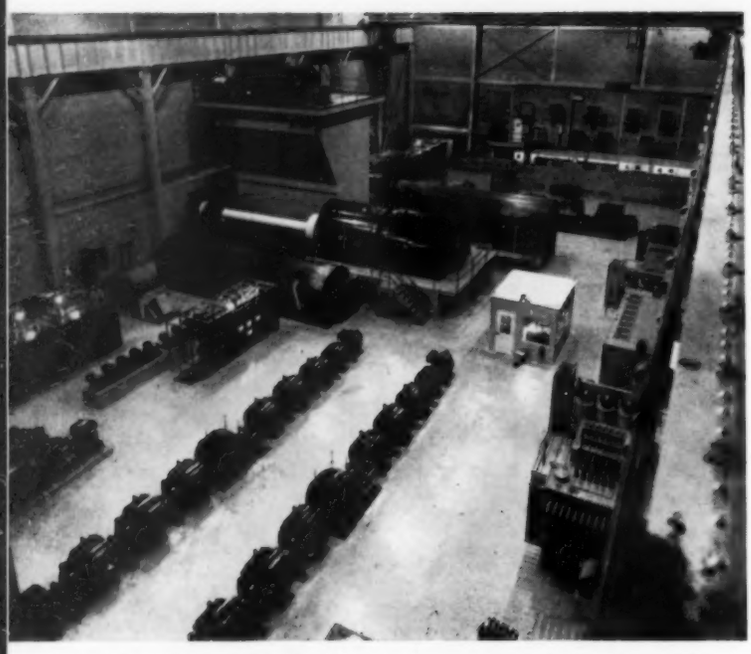


Figure 9 — Motor room for the Great Lakes Steel Corp., 16,000-hp universal slabbing mill. In the background is the 12,000-hp, 40-rpm, double armature twin drive for the horizontal rolls, the 4000-hp, 60-rpm motor for the vertical rolls, and the flywheel motor-generator set. In the foreground are the auxiliary motor-generator sets, ignitron rectifier for constant voltage direct-current supply, and other associated equipment.

rolls, manipulators, horizontal roll screw-downs, vertical roll adjustment, and fingers.

Four regulating systems are used for control of the variable voltage scarfer table drives.

One system is used for the voltage control of the constant potential exciter serving the main variable voltage drives.

The use of regulating systems properly applied is one of the major factors in the ease of handling and smoothness with which a few men control such a large amount of complex electrical equipment.

Present-day regulators are wonderful devices, but to obtain optimum results other components must be carefully selected and coordinated into the drive system. Exciter size and ceiling voltage, damping devices for stability, time constants of all components, generator and motor saturation, speed-load or voltage-load characteristics, and overall system gain, are all important and merit full consideration in the design of a regulated drive system.

DISCUSSION

PRESENTED BY

E. E. CHEEK, Blast Furnace and Coke Ovens Area Engineer, Ford Motor Co., Dearborn, Mich.

W. R. HARRIS, Manager, Industry Engineering, Westinghouse Electric Corp., East Pittsburgh, Pa.

Edward E. Cheek: How do exciter ratings on modern blooming mill rods compare with those on old ones?

W. R. Harris: In response to Mr. Cheek's question, in general, the exciter ratings for modern mills are very much in excess of the ratings on the mills furnished several years ago. Most of the older mills reverse in from two to three seconds, and in most cases the exciter sizes were 1½ to 2 times the normal excitation requirements. When these drives are revamped, we invariably have to supply new exciters in order to get reversal times of from 1½ to 2 seconds. Depending on reversal time and main equipment time constants, the exciters for the generators range from six to ten times the normal field excitation requirement.

"REGULATOR DEVELOPMENT AND FUTURE TRENDS"

By ROBERT C. SUTTLE

Application Engineer

Reliance Electric and Engineering Co.

Cleveland, Ohio

▲ THE first regulator which we find in use came into being in the 1920's. It was a mechanical type regulator —really could be said to have been electro-mechanical in nature—and was usually controlled by some rheostatic type device. Looking back, it seems as though there were really hundreds of such regulators on the market in those days. Reviewing the trade and technical paper descriptions of them it appears that the first ones were galvanometer-type instruments. They approached what we term "laboratory instruments." They were delicate. One day they would be very stable; the next day, they would be wild.

As a matter of fact, these first regulators were used largely as voltage regulators on a constant potential supply—as in power houses. They also had limited applications in the paper and textile fields.

In the 1930's with some improvements added, there appeared a device which was solenoid-operated instead of galvanometer-operated. It was more rugged; and better able to stand the brunt of normal plant maintenance.

During the early 1930's many regulators of this type were put into use. For example, a considerable number of foil mills were put into operation in the aluminum industry, using this type of regulator for tension or voltage control. Even the voltage regulator in your car makes use of this same type of design. It might be said, therefore, to be in wide usage even today.

The next type of regulator to be developed made use of the metadyne principle, which is basically a cascading of generators, usually a control exciter with multiple field controlling an output exciter. This type was introduced in Europe in the late 1930's and into this country in about 1938.

Great interest was placed in this regulator; and great promise resulted from initial installations. However, the war time restriction of electrical equipment dictated that the metadyne type regulator be allocated to military use. As a result, during the period from 1940 to 1946 we had limited industrial usage of this device. We had to live on what we already had at that time.

In 1946 after rotating regulators were released from military restrictions, they were universally accepted. They did, and are doing, an outstanding job.

The next regulator, which from the standpoint of time followed somewhat the same path as the metadyne regulator, was the electronic type unit. Its initial industrial application followed the development of the thyratron in 1938. This was about the same time that the metadyne type regulator was introduced.

The first thyratrons to be applied in industry were given a big fanfare, and they were introduced as a cure-all to all control problems. However, like most things that are highly publicized before having actual field tests, there were drawbacks. For no apparent reason, even after a considerable run-in period, tubes failed. The tube manufacturers were very much interested and devoted time and effort to correcting these faults, but with the increasing military demands they were not able to make very substantial progress with thyratrons before we went into World War II.

So, the first days of electronic regulators were disappointing ones. During the war, the uses of electronics by the military services were broad. They, also, experienced some bitter application experiences at the start. However, with the emphasis on defense production and the vital importance attached to unfailing performances, they were justified in demanding and ultimately obtaining perfection. As a result, we now have tubes which are very rugged.

During this period technical attention was being concentrated on military applications. It was not until late in 1946, at the end of the war, that electronics were released for industrial use.

Great improvements had been made. We had improved tubes, ruggedized tubes, and—more recently—better circuit elements, resistors and condensors which will stand up under high heat and conditions of great humidity.

The next development of regulators was the magnetic amplifier. This amplifier, as such is new. We knew its predecessor, the saturated reactor, very well. Many saturated reactors have been used on open loop control systems. They were used on theater dimmers in 1920. In 1930, they were in extensive use in welding control. So, the saturated reactor, the forerunner of the magnetic amplifier had become pretty well accepted before the war.

The actual self-saturating characteristics that we know in magnetic amplifiers today were obtained by us from the Germans, some under actual combat conditions. The first magnetic amplifiers, for example, were found on downed German planes during World War II. At that time, their discovery was classified as confidential.

It was not until after the end of World War II, that information on magnetic amplifiers was released generally by the Armed Forces and it was 1946, therefore, before the magnetic amplifiers were released for industrial use. Not too much was known about them. In fact, it was pretty much left up to the manufacturing end of the electrical industry to do a lot of development work. This was of necessity quite extensive to meet the needs for industrial usage. For example, special core materials had to be developed. Strip had to be rolled that was below one thousandth in thickness. It had to be done with close tolerances. New winding techniques had to be developed. Magnetic amplifiers are indeed new, and it looks as though they have a great deal of promise.

More recently, the usefulness of industrial regulators has been extended by the analog computor. With the use of this device, an entire system—generators, motors, and the mechanical loads anticipated on a given machine, can be mathematically simulated.

This means that the operating conditions to be satisfied by the electric motors and associated controls constituting the overall drive can be studied in great detail at various operating loads and speeds.

It also means that we are now able to eliminate most of the field test and start-up time that we previously had to go through with the earlier types of regulators. As a result, we are able right at the outset to give better guidance to our control engineer in the use of regulators.

Analog studies have shown that our circuit design, as well as our selection of motors and generators, need to be reviewed more critically. Even some of the undesirable mechanical characteristics of a machine show up under such studies.

This, then, is the point at which we find ourselves at the present time. We are possessed of a tremendous background on regulators. We also have a wealth of operating experience upon which to draw.

To summarize briefly, as far as the electro-mechanical type of regulators are concerned, we do not want a device that is purely a laboratory type; we want something that will stand normal plant conditions and maintenance. We also found it essential that we have a better means of stabilization.

For another thing, we do not want to have to tailor the regulator for every specific application. The ideal would be to get one regulator that we could use universally. We would have a much better cost factor, and we would be in a much better position to supply a more economical regulating system.

As for the rotating regulator, we needed something that had a very fast response; something with a low time constant, something that did not interpose a delay when going through a series of stages. We needed an increased voltage gain to get better accuracy. We wanted a high power gain so as to impose a low burden on the input circuits. We wanted to eliminate the mutual inductive effect of separate windings, and the heating variable of these windings.

So far as electronic regulators were concerned, we have experienced the need for more rugged elements—not only tubes—but circuit devices, condensors, and resistors as well. We want a regulator whose effects of circuit grounds can be minimized, or one which does not require elaborate shielding from associated devices. And lastly, we want a regulator whose component parts are readily available from normal maintenance stocks.

One might say: We know all this; we have the experience. We have the computors. Where do we turn next?

We can see that the magnetic amplifier certainly offers promise which we have not as yet fully exploited. There is a lot of work to be done. In electronics, we

have the new ruggedized miniatures which have come out of the recent joint Army and Navy developments. Tubes with 20 years of life will be available shortly. We have transistors coming into the picture. We are going to have improved generators and motors, generators and motors that are designed for use specifically with closed loop systems.

Last but by no means least, we have the unknown factor of atomic energy coming into the picture. So, you see, we are on the eve of an era where for the first time we have unlimited use for this wealth of background material. Out of further study and experimentation I am sure that we are going to get a regulator which will really do its job and keep pace with the ever increasing requirements of industry.

DISCUSSION

PRESENTED BY

A. J. SAMUELS, Electrical Engineer and Draftsman, Great Lakes Steel Corp., Ecorse, Detroit, Mich.

ROBERT C. SUTTLE, Application Engineer, Reliance Electric and Engineering Co., Cleveland, Ohio.

HARRY G. SCHORR, Electrical Estimator, Triangle Electric Co., Detroit, Mich.

A. J. Samuels: Have any regulators been applied or built using transistors?

R. C. Suttle: We have made some pilot installations, one of them in our own plant. The most successful one, to date, is in a building which is air-conditioned and with the humidity closely controlled. Most of us are aware of the removal of transistors from the hearing-aid market because it was found that they failed at body temperature and were otherwise subject to short-life under humid conditions. So, for the moment at least, it has been determined that the germanium transistor offers promise only where operating conditions of temperature and humidity are closely controlled.

A new silicon cell, however, has shown great promise. Because it does not have the limitations imposed by temperature and humidity mentioned, it will undoubtedly replace the germanium cell being used at the present time. It may be some time, however, before wide industrial use is made of transistors.

Specifically as to the regulator in which we are using transistors today—it is in the amplifier and detector stages of a thyratron control circuit. When the new silicon cells have been more fully developed, we may have a device that will be of great service in the industrial field.

Harry G. Schorr: What are the quantities of regulators of various types that are in use on an average today?

R. C. Suttle: I assume you are referring to the types of regulators which have been installed by our company. Even so, to answer your question I shall have to use approximations for all except the most recent types which, of course, are the magnetic amplifier and the electronic.

As for the rheostatic type regulator which we have used largely in the steel, nonferrous and paper industries, I suppose we have somewhere in the neighborhood of 1000 applications. Of the rotating type regulator, we have produced and installed something over 5000. As far as the electronic regulator is concerned, we have installed approximately 10,000 units.

On magnetic amplifiers, I do not have the figures readily available. The first installation was made in 1947 in one of the steel mills in the Chicago area. It was on a job which the rotating regulator could not handle satisfactorily. Offhand, I would venture to say that we probably have in the neighborhood of 100 to 200 applications of magnetic amplifiers throughout all industry.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Erection and Operation of Blast Furnaces in Chile

By THOMAS W. PLANTE
Consultant
Pittsburgh, Pa.

. . . . skilled American steel plant operators are carrying their knowledge to all parts of the world . . . . much ingenuity and skill is required on their part to overcome local problems such as training of unskilled personnel, climatic conditions, raw materials which differ from those available in the United States and distances from ordinary sources of supply . . . .

▲ THE long slender country forming the lower portion of the west coast of South America, Chile extends from the 18th to the 55th parallel South, and has a length of some 2800 miles. Its greatest width is about two hundred miles in the north near the Tropic of Capricorn. Narrowing to the south, the width shrinks to less than 100 miles. Its very effective eastern boundary are the towering Andes, which include many volcanoes which occasionally show activity by emitting clouds of smoke and steam. Here too are many termas, or hot springs, which serve as health resorts where often the sides of the mountains are so warm that the unwary pedestrian is surprised with two king-sized hot feet. On the west, the Andes are bordered by the Great Central Plain, a wide and almost perfectly flat area which parallels the mountains for hundreds of miles. At scattered intervals, rivers formed by the melting snows of the Andes cross this plain westward towards the Pacific Ocean. Often the streams diminish in size as they sweep to the coast, being tapped for irrigation. The Plain is bounded on the west by the Coastal Cordillera, a mountain range only half a mile or so high. This range plunges abruptly into the Pacific, thus limiting the number of port sites to very few, despite the tremendously long coastline.

With its length running from north to south, Chile has its own type of climate. In the north rainfall is practically unknown and the result is strictly desert. As one proceeds south there is no doubt about the rain which progressively increases until in the far south there are ten months of continuous heavy rain. Thus there are really only two seasons, usually a very dry summer and a terrifically wet winter. Snow occurs only in the Andes, and occasionally in Santiago, the Capital, which is rather high and ringed by snow-clad mountains. At the steel plant where we were located some 350 miles south of Santiago, there was a soaking wet winter of about four months followed by eight months of dry summer. Many times during the winter there would be as much as fifteen in. of rain in five days, in this country this would mean fifteen cloudbursts; there it was simply a heavy rain.

Hydro-electric plants utilizing part of the great power potential of the Andean snows are the main source of power. Presently only scattered units, they will be integrated into one great system. Power for the mill originated at the hydro-electric plant at Laja.

Transportation is a major problem. The state-owned railway line runs the entire length of the Great Central Plain, with branches tapping off here and there to either side. One train never runs away from its connection, and any delay is cumulative, which makes the length of Chile seem like 10,000 miles. One of the dire needs of the country is a good road system. There are only a few concrete roads; the majority are simply dirt with a few graded with rock ballast, while most are suitable only for the thousands of ox-carts which ply them. In the rainy season, even the oxen have to give up. Therefore huge areas which could produce no end of useful crops lie unproductive, simply for lack of transportation. Time will correct this, but it will take many years. At three points, the Pan American highway is being worked on, and Chile is second only to Peru in the work completed. I doubt, however, that

even your great grandchildren will be able to drive a car to Chile, due to obstacles in the countries nearer the Isthmus.

Black hair and dark eyes predominate among the people—a heritage from their Spanish ancestors, although traces of more northerly European forebears are noted, and one of their great national heroes, Senor O'Higgins helped liberate the country. The original occupants of the land were the Araucanian Indians, who alone seem to have retained their racial characteristics. Never conquered by the Spaniards, they have developed into an agricultural people of whom Chile can well be proud. All of the children are eager to learn, and they are quite as intelligent as the young people in the States. They are more serious about learning than our own youngsters, perhaps because there are not so many extra-curricular subjects and other distractions. However, free public education is available only up to about the sixth grade. Once this deficiency is corrected, Chile will go forward by leaps and bounds.

Southern European customs are in vogue. Courtesy is more pronounced than in Europe, and it only makes the observer wish that it were more prevalent universally. Since Chile produces better wines and champagne than does France, drinking is common—but one never sees a Chileno under the influence; for moderation is the rule. Eating habits were the most disconcerting. A light breakfast, then a 10:30 coffee break, then a two hour lunch, then a five o'clock tea hour, and a final dinner never before nine o'clock went far towards upsetting the normal schedule of a North American steel operator. In our own homes we quickly reverted to average U. S. style eating. In the mill we had to arrange for special dispensations to follow Stateside practices on turn jobs.

With this background we are now in better position to discuss the mill. Huachipato, as the new steel plant is named, was the result of many long years of dreaming and planning by a group of the more progressive Chilenos. Its true godfather was the Corporation de Fomento, an organization for the encouragement of development of various phases of industrial activity which would further the progress of the country. With all of the basic natural resources available, steel production was more or less a "natural." Formation of the Compania de Acero del Pacifico—Pacific Steel Co.—was accomplished by private Chileno capital, and the Export Import Bank gave its final blessing in the shape of a substantial loan.

A fully integrated plant was planned, consisting of a battery of 57 coke ovens, a blast furnace scheduled to produce 562 metric tons of iron daily, two open hearths, a bessemer, blooming mill, rod and bar and sheet and tin plate mill. The products were light plate, tin plate, corrugated sheets, rods and concrete reinforcing bars to the extent of some 250,000 tons yearly. No heavy structural steel rolling was planned.

The location was practically automatically determined. At one of the few port sites available there existed other favorable factors. Only three miles south one of the few large rivers—the Bio Bio—emptied into the Pacific, thus insuring a reliable ample supply of fresh water so essential to any steel plant. Fifteen miles to the south were the national coal mines. A scant two

Figure 1 — The Bio Bio changed its channel leaving a half-moon bay. Water shipment supplies most of the materials for the plant.

miles to the north was another harbor which sheltered Chile's naval base of Talcahuano. About nine miles inland, and situated on the Bio Bio River was the four hundred year old city of Concepcion in which lived some 110,000 people and which had rail connections with the main line. All of these factors made the location ideal.

Ages back the Bio Bio had worked for other ages carrying black volcanic sand down from the Andes and depositing it where it met the Pacific in a sort of half circle of low surrounding hills. After filling a goodly portion of the area it had done its work too well and was forced to seek another outlet to the sea, or perhaps an earthquake helped it to change its direction. At any rate its present outlet is three miles further down the coast, and where it had been was a half-moon shaped bay about two miles in diameter fronting directly on the Pacific Ocean. The shore line was solid black sand which extended back about half a mile in a series of rolling sand dunes to the low-lying hills. A dense forest of pines covered the dunes. The trees were completely razed at start of construction, although we later wished many had been saved.

The nearby hills were used as a location for a water reservoir which served as an excellent plant stand-pipe. Water was pumped about four miles from the Bio Bio to the reservoir where the sand settled out, and we then had an ample supply of cool fresh water for all purposes. Drinking water was processed in the mill.

One of the first jobs was the erection of a dock for the handling of inbound raw materials and outbound finished products. This pier extended 1100 ft into San Vicente Bay, as the harbor is called, and is equipped with the necessary railroad tracks and an unloading tower which discharged either to a conveyor belt for carrying the raw materials inland or to cars. The initial heavy construction equipment was handled over the naval piers at Talcahuano. Facing directly on the Pacific, the six ft swell presented problems when loading or discharging vessels, but it is believed that a partially submerged reef extending from the northern army of the bay will be eventually utilized to form part of a breakwater.

Normal flow of the raw materials from the ships was as follows. Unloaded from the vessels' hatches by the

tower unloader, the iron ore passed through a receiving hopper located on the tower onto a belt conveyor which carried the material shoreward where it was discharged into a scalping and crushing building. The oversize was crushed and joined the by-pass stream on another conveyor which discharged to a screening station. Here portions of the ore fines could be removed to satisfy the demands of the small sintering plant for the necessary tonnage. Another conveyor running along all of the storage beds then carried the ore to the proper storage bed where a tripper fed the ore to the individual belts serving the beds. A travelling stacker then deposited the ore in the usual long windrows the length of the bed. Each cargo was divided between at least two beds; so that a completed bed of 9500 tons was composed of two half cargoes. This portion of the system was believed to be responsible for at least 85 per cent of the blending effect. When the ore was reclaimed and taken to the stockhouse bins, again by belt, further mixing was obtained by closely controlled bin distribution and by rotational withdrawal by the stockhouse larry. The system proved quite effective in reducing swings in ore analyses.

The iron ore was obtained from the El Tofo mine located north of La Serena in Chile. Located in an arid region the "mine" was actually the top of a mountain not far from the shores of the Pacific, and the ore trains winding down the steep grade to the seaside loading dock generated power during their descent. The ore was very refractory, and was also the most abrasive the writer has seen. Small lumps could be heated to a white hotness with no sign of decrepitation, and very high blast heat was required to accomplish the great amount of direct reduction. The analyses was approximately 55.3 to 57.9 Fe; 8.95 to 12.5 SiO_2; 0.035 to 0.062 phos; 1.8 to 2.6 alumina; 0.30 vanadium; and 0.55 to 0.66 per cent titania.

The limestone was boated in from Madre de Dios, an island some 850 miles closer to the South Pole. Chemically very pure, it was very hard and greatly resembled the limestone from some central Pennsylvania quarries. It was quite friable and produced large quantities of fines when mined and crushed. It followed the same flow as the iron ore, but when it reached the screening station it was diverted to an adjoining building where we installed a washing plant which was very effective in removing the large quantity of fines. After washing it was stored in its assigned bed for later recovery and use. The magnesia content was practically nil; so we had to satisfy the furnace demand for that by using dolomite obtained from a mine in the Andes. The titania in the slag made the use of dolomite mandatory; for thinning the slag by using sand was out of the question due to the latter's extraordinary high alumina content. Neither was high silica gravel readily available at that time.

Since the national coal would not in itself produce a suitable metallurgical coke, it was necessary to import U. S. medium low volatile coal. From the vessel the coal utilized the shoreward conveyor from the pier, but at the crushing station it was diverted to the conveyor which carried it to the coal storage area where it was piled by means of a rotary stocker. Reclaimed from the stocking area by bulldozers to underground conveyors

Figure 2 — Ore comes from the El Tofo mine.

it was carried to the coal bins by belt. National coal, arriving by railway car with a fourteen mile haul, was unloaded into track hoppers which also fed to the belt system. By using U. S. coal to the extent of from 30 to 50 per cent in the coal mix, the coke produced was of fair quality, with stabilities of from 41.3 to 47.8 per cent. That was the only test we made. The coke was transported directly from the coke wharf to the stockhouse bins by belt, and the only screening it received was over ¾-in. screens as it was measured into the hoppers over the skip buckets. Although the hoppers were equipped with weightometers, we measured the coke by volume only; for during the heavy rains the coke would pick up as much as 18 per cent by weight of water as it was being transported.

With practically all of the materials completely avoiding rail transportation, one of the usual blast furnace headaches was eliminated. Incidentally the standard rail gage for the country is 5 ft 6 in.

Being the first portion of the mill to be worked on, the coke works were well along by April 1949 and enough furnace foundations had been completed to start work on the latter. Just about that time there were what appeared to be mountains of material on every side. It should be remembered that we were not in the States where materials could be scheduled to arrive at the instant needed; instead we were over 7000 miles away, and space is not always available on ships, nor is their arrival time so definite. So we had to have nearly everything we needed immediately at hand. Order was finally evolved out of the seeming chaos and good progress was made.

The Araucanian Indians called Chile the "Land of the Trembling Earth." The name was well-deserved, and earthquake engineering entered into every phase of design for the plant. It employs calculations too complex for a mere blast furnace operator, and we simply mention that it involves questions of rigidity, low center of mass, vibration, and several other considerations. So far as the blast furnace was concerned, it resulted in an outsize foundation and a radical departure from standard design, plus a reduction in height wherever possible.

The furnace foundation was octagonal in shape with a diameter of 100 ft, resting on an area which had been carefully compacted by driving some 250 concrete pilings. The Chileno earthquake specialists deemed the

compaction piling method best, since heavy black volcanic sand occupied most of the 90 ft between solid rock and the plant ground level of just a little more than 17 ft above mean high tide. The hot blast stove foundations followed a similar pattern, the stoves resting on a pad measuring 50 ft by 90 ft. Slightly greater distance was permitted between stoves and furnace than is usual, again for earthquake reasons.

Of particular interest was the design for the lower portion of the furnace. Instead of separate base ring, columns and mantle, these three items constituted a single unit. The base ring was a welded box-like ring of 1½-in. steel plates, the plan section being roughly octagonal in shape. Integral with the base ring, eight box type columns, again of 1½-in. welded plate, rose to merge into the box type mantle. The entire assembly resembled a slightly tapered squirrel cage. The furnace shell of 1⅛ and 1-in. plate was also welded and was integral with the mantle. Thus the whole structure satisfied the earthquake demands for rigidity. Fabrication was done in the States, and when assembled in Chile fitted together beautifully. Incidentally the entire plant was of welded construction, all of the welding being done by Chilenos who were trained on the job, and the excellence of their training and work was well tested and proven by subsequent earthquakes, which will be discussed later.

The furnace hearth was 20 ft in diameter, the stockline 18 ft, and the bosh 23 ft-10 in., with a 13-ft diameter large bell. Inwall batter was 0.859 in. and the bosh angle 80 degrees. The working volume was 23,800 cu ft. The furnace had twelve tuyeres and a carbon hearth. The latter was 27 in. thick on the bottom with double side walls totalling 30 in. thick. The carbon extended up 10 ft 5 in. to the bottom of the tuyere coolers on the inner side wall, while the outer terminated 2 ft-11 in. lower. A continuous light steel inner lining, which we called a "tin can," was fitted as tightly as possible against the hearth cooling staves to minimize water leakage to the carbon. The small space between the hearth staves and the tin can was filled with grout. The space between the tin can and the carbon wall was not filled with coke braize; instead we used ramming mix and while ramming, we embedded therein as many carbon brick and carbon splits as possible; likewise for ramming between the two carbon walls. We believe this was the first time this was done, and no trouble of any kind resulted from this procedure.

Four gas offtakes merge upwards into two risers, each equipped with a bleeder, while a single downcomer enters the central entry type of dust catcher. The latter was equipped with a single explosion valve and also with a bleeder. Due to cutting of the valve seat by dirty gas, the bleeder was subsequently moved to a location where clean gas could be bled.

Three 21 by 94-ft stoves with checkers afforded a heating surface of 360,000 sq ft, permitting a blast temperature of 1450 when blowing 47,000 cu ft of wind. Due to heat demands of the furnace, a fourth stove was later added.

The stockhouse consisted of steel bins, six measuring 20 ft wide by 15 ft long and two measuring 7 ft-6 in. long, all resting on a single concrete pad. Capacity of the larger bins was 375 metric tons of ore or 250 metric

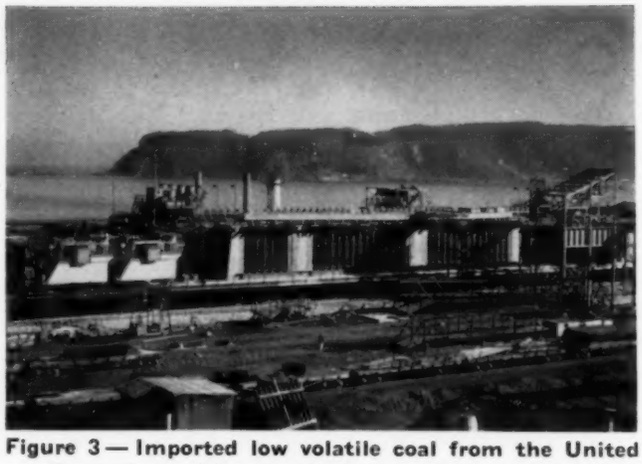

Figure 3 — Imported low volatile coal from the United States is used in quantities up to 50 per cent of the coal mix.

tons of limestone. All were equipped with hand-operated quadrant type gates. The two coke bins, also of steel with tile-lined bottoms, measured 28 ft wide and 33 ft-6 in. long and had a total capacity of 350 metric tons of coke. Slides at each end of both bins minimized the falling distance of coke in the event of "low" bins. Above the bins were mounted two belts with trippers, one for coke only, the other for all other materials arriving from the storage yard. With the much higher than anticipated production of the furnace it was necessary to later add additional bins.

For blowing we had two centrifugals, each driven with a 6000-hp electric motor. Capacity of each was 50,000 cfm at 30 psi pressure. Power for the operation was obtained from the hydro-electric plant at Laja in the Andes. As a precaution against power failures, a steam-driven centrifugal blower with a capacity of 20,000 cfm at 10 psi gage was so interconnected that either a power failure or a drop in blast pressure would automatically put it into operation. By continually circulating oil through the bearings we were able to have the blower in full operation in less than 20 seconds. Since power failures averaged 18 per year, many times the steam blower kept slag out of the blowpipes; for when a power failure did occur, the blast would go off just like a light going out. Being connected to "kick in" on every pressure drop, the steam blower would do so on every cast; thus we had a five-times-daily check on its availability.

A partial listing of the standard equipment installed was as follows:

Automatic charging control and double-engine skip hoist, stove burners, chimney valves, and hot blast valves; distributor, dust catcher pug mill, gas main valves, stove blow-off valves, cold blast valves, anti-explosion valve and snort valve in the cold blast main; hot blast stoves and gas washer; precipitator; electric clay gun; and iron ladles.

The gas was handled through a 30-ft diameter dust catcher, then through an 18 ft diameter gas washer, static type with four banks of tile; thence through a double-chamber type precipitator. The system was good, except that until a limestone washer was completed, considerable difficulty was experienced in removing the fine limestone dust which was blown from the furnace. Blast furnace gas was of course used in

the stoves, and also after passing through a second precipitator used to underfire the coke ovens. The excess was mixed with coke oven gas for mill heating purposes and for sale outside to various commercial users and to the city gas distribution system of Concepcion. The high cost of coal made the sale of auxiliary fuel quite attractive.

For the erection of the furnace, normal North American procedures were followed, except that we used powdered sillimanite as the bonding material for all bosh brickwork, as well as for the joint between the carbon and the ceramic materials. Erection was not that achieved in the States. During the rainy season downpours often prohibited work of any kind. However by May of 1950 we had progressed far enough to dry out the furnace. The hot blast stoves were first dried out using wood then later gas from the gas producers which had been used to heat the coke ovens. Due to the hot sharp flame of producer gas it was essential to use extreme care when using it to heat the stoves. With plenty of stove heat available, we used hot blast to dry the furnace, and we had the most thorough of any in my experience. The heat was worked slowly up to 1100 F and then held there for eighteen days. In addition to the complete dry-out of the furnace, this gave us a chance to train the stove tenders in their duties prior to blowing in.

Training the crews was a bit involved and quite interesting. With the construction crews still working to complete the remainder of the plant, we could not recruit men from their ranks; so we had to obtain them from the fields and the ox carts. Some reported for work quite unsuitably clad; so the first job was to correct that condition. None could speak English, and my few supervisors and myself could utter but few words in Spanish. However, we had a number of Chileno college graduates whom we had farmed out for a brief time at mills in the States so they at least knew what a furnace looked like. They acted as interpreters, being assigned one to each supervisor. The latter we had chosen from various plants in the U. S., to the extent of three turn foremen, three blowers and one relief man, one stockhouse foreman, and one tower unloader operator for the dock. We then combined the good practices of each plant so represented and worked out a standard cast house practice which gave excellent results. The men were eager to learn, and developed into workers to compare with the best in the States. The Chilenos had no bad habits to unlearn, and they developed a tremendous job pride. Never before had I seen a stockhouse man with his finger poised on the control button waiting for the gage to show time for another charge. The larry car was not only blown off every turn but wiped off as well, and the cast house crews were equally clean. They liked to paint in their spare moments; so we managed to have brushes and plenty of black and yellow paint convenient. To them nothing looked better than a shining black ladle with yellow trimmings, brake wheels and stirrups—I rather liked it myself. We installed the first mill flower garden around the buildings which served as our combined blast furnace and coke works offices and locker room, and the men were always bringing some new flower or shrub to plant in it. The habit spread to other departments also. In the matter of teaching safety we were less fortunate. The Chileno is naturally brave and just as naturally fails to recognize the fact that wearing safety equipment is not an act of cowardice. However, when a hard hat or an asbestos coverall was pointed out as part of a uniform it was difficult to make the men part with them when the need for them was not present. But all in all we enjoyed an unbelievably good accident-free experience.

Figure 4 — The base ring, columns and mantle of the blast furnace constitute a single unit.

We were ready to go into blast on June 1, and the furnace was lighted at a carefully planned hour so that the first cast would occur in the deep stretches of the night; for we desired to be more or less alone for the first tap. Despite very hush-hush arrangements, when cast time arrived some thirty-two hours later, the cast house was full of dignitaries plus about half the news reporters of the country. The cast was quite successful and everything went off like clockwork. It was really something to see those men standing there crying tears of joy as the iron was coming from the furnace—to them it was the culmination of a long-time dream.

Operating only on the materials mentioned earlier, that is iron ore, limestone, dolomite and coke, plus a small amount of manganese ore, the furnace operation was one of the smoothest I have seen anywhere. Due to climatic conditions the humidity would run for days at a time at 100 per cent, even in the summer when there was no rain, but the furnace seemed to like it.

With no scrap, sinter or roll scale, average monthly production varied between 785 and 826 net tons daily on coke rates of from 1680 to 1780 lb per net ton. This was equivalent to a production of 33.0 to 34.6 net ton daily per 1000 cu ft of working volume, surpassed, I believe, only by certain furnaces in Sweden which operate on entirely different burdens. Due to heat limitations, the furnace was never up to full potential production since we were able to blow only 47,300 cu ft of wind and still maintain 1450 F blast temperature. The furnace practically begged for more heat. The recent addition of a fourth stove and 13 additional coke ovens have eliminated that drawback. Also the addition of a small sinter plant has permitted the treatment of a portion of the ore fines, but the furnace has never had the opportunity to show what it could do with say 30 per cent of good sinter in the burden.

Iron analyses was exceptionally good. We had to produce a compromise grade which could be used at will as bessemer, or open hearth or foundry iron. Percentage of iron within specifications varied from 90.5 to 92.5, said specifications being from 1.10 to 1.50 per cent silicon with normal low sulphurs. Analyses averaged 1.30 to 1.39 silicon; 0.035 sulphur; 0.082 to 0.112 phos; 0.38 to 0.41 manganese; 0.10 titanium; and 0.35 per cent vanadium. Flue dust was from 14 to 20 lb per ton of metal, and slag volume 1080 lb per net ton on a 1.28 to 1.34 slag ratio. Slag analyses was 34.5 to 35.3 silica; 12.8 to 13.7 alumina; 35.8 to 37.9 lime; 8.3 to 8.8 magnesia; 1.3 to 1.7 titania; and 1.1 per cent sulphur. During the last six months I was there we changed only six tuyeres, two of which were withdrawn simply on account of old age; but during the same period, 29 monkeys were burned due to the high titania content of the slag.

About four months after we blew in, the rest of the mill was almost completed. At the same time Concepcion, the city in which we lived, was celebrating the 400th anniversary of its founding. A big part of the celebration was the dedication of the mill, and being the tallest man-made structure in Chile the blast furnace was chosen to represent the entire plant. We decorated the area in nice style, borrowing every naval signal flag available in Talcahuano, and erecting a platform hung with the red, white and blue of Chile. In the afternoon the Chileno "West Pointers" formed a hollow square at the furnace and the Archbishop baptized a baby as being symbolical of the plant, with President Gonzales' senora acting as Godmother. It was very impressive. Open house for everybody followed a short time later and crowds simply swamped the plant. I clocked people filing into the cast house at an average of 110 per minute, and this continued for hours. Thousands of babies and even the family pets were in the crowd. Surprisingly there was not a single mishap of any kind, and I truly believe every inhabitant of Concepcion, Talcahuano, and the score of smaller towns nearby visited the mill. Needless to say they were greatly interested, but all of the supervisors playing guardian angels were nervous wrecks when the gates closed just before dark.

After the dedication the mill continued to run like a charm. True, contingencies arose which did not permit solutions such as are available to Stateside operators

Figure 5 — The plant was dedicated on November 24, 1950. This was regarded as an important event by the Chilenos.

who have help almost next door. We were 7500 miles away from aid, but the ingenuity of the U. S. personnel led to satisfactory if somewhat unorthodox answers. The interruptions at the blast furnace were so few that the opportunities for the Chileno trainee to gain experience the "hard way" were almost nil. However there were some occurrences worthy of mention. Prior to installation of the limestone washing plant, the fine dust in the limestone tended to blow out of the burden. Not all passed out of the furnace in the gas stream. Some deposited in the expanded top and the gradual buildup tended to choke off the top. It was then necessary to drive a few two-in. pipe flattened at one end into the hard ring of caked dust, push into the pipe a small charge of dynamite and explode it. Care was taken to keep the charges a short distance from the brickwork, and the boys became so expert in "blowing" the line that the whole job would require only about an hour and a half.

Then of course we had the earthquakes. Not all were dangerous, and most of them consisted simply of a jolt or two. The bad thing about a quake is that one never knows how long it will last. Our worst one would rate as a first class nightmare for any blast furnace operator. This will be described in the form of a story. It was the custom for a few of the superintendents to drop into my office for lunch which we always carried, not caring to take the long more or less formal affair as many did.

Figure 6 — Blast furnace operation has been very satisfactory.

We were just finishing when we felt the rumble of a heavy tractor going past the office. It was quite loud and I craned my neck to look out the window. I could see no tractor but I did notice a crack starting to open in a corner of my concrete reinforced office. I shouted outside, and we still have not figured who was first out. By that time the quake was well under way. The overhead thirty-in. gas line extending half a mile or so down the yard was writhing just like a clothlines being wriggled. We got out from under that with difficulty; for the ground was heaving up and down about two ft. The blast furnace was waving around in the air with an arc of about four ft.

The hot blast stoves were doing even better, performing a quite terrifying dance, while the stove stack was swinging in a circle still larger. The dust catcher and gas washer had also joined the chorus line. We could see up through the cinder runner opening into the cast-house and there was a hot iron glow at the tap hole. It was cast time, but I did not know whether the furnace had just been tapped or whether the quake had split the hearth. Just at that instant, the three big iron ladles came running out from under the cast house—running uphill, and without an engine; they sailed up the track about a hundred yards before coming to a halt. Of course the cast house crew unloaded from the cast house too; for we had given them orders to do so in the event of a heavy quake, in case blow-pipes were shaken down. They ran only to the point where we were standing, and I will admit we had one foot pointed in the right direction in case the furnace started to topple. All the time the air seemed to be streaked with red, blue and green flashes, but there was nothing imaginary about the groaning and creaking of the earth. To top it all I could see the end of the furnace and perhaps the whole plant, which added nothing to peace of mind. Time seemed endless, but the actual duration of the quake was two and a half minutes. The tremor stopped then and we rushed for the cast house, not a single one of the crew failing to follow. One of the Chileno foremen ran up the track and corralled the engine which had spotted the ladles, and then pulled up the track for lunch. They backed into the ladles and got them back under the iron spouts just as the iron poured out of the first one, and not a drop was lost. The tap hole had just been lanced, and it had taken just about three minutes for the iron to fill the main trough. Of course the power had failed, but the steam line to the auxiliary blower was intact, and once again the standby had saved our necks. We finished the cast on the lower pressure, and after about half an hour the electric power was restored; so we put the blast on full immediately to see whether the furnace had been damaged.

A hasty inspection disclosed no trouble "downstairs"; so we went on top and could find no damage there except that a three-in. pipe flagpole on top of one of the bleeders had been bent into the shape of a hairpin. Crossing back over the bridge between the furnace and number one stove we found the bridge hanging by a mere thread — the bridge just could not stretch enough to compensate for the wild swings the furnace and stoves had just undergone. Back on the ground dirt marks on the foundation showed that everything had been severely shaken, but fortunately too everything had gone back to original positions. The unloading pier had heaved shoreward about eighteen in. and had then resumed its normal position. We hastily put transits on the furnace and it still showed plumb. All through the mill reports were the same—no damage. Our home town had not been so fortunate—scores of buildings had been tumbled down and a few people killed in nearby areas, but the fact that the quake had occurred when practically all the populace was home for their long lunch contributed much to the low casualty list. While quakes were not at all uncommon, we never did get used to them; even a relatively short jolt stayed in one's mind for a while.

There was plenty to occupy one's leisure moments away from the mill. The city of Concepcion in which we lived was just nine miles from the plant by a good concrete road, and numbered 110,000 inhabitants. There were sufficient movies in English, Spanish and French, and enough night clubs and kindred entertainment to satisfy the needs of all. Social activities abounded and there was a quite active interest in the arts. The oldest golf course in Chile lay just outside the town limits and we played twelve months a year. Nearby a three-track race course operated every Saturday, Sunday and holiday. Wild game larger than a Belgian hare was unknown, but the size and number of the fish made enthusiasts out of even the most lukewarm Isaak Waltons. We had to throw back all the rainbow trout under fifteen in., and we caught one which measured 38 in., with average sizes being from eighteen to twenty-six in. Of course there was always deep sea fishing right off the plant pier, with plenty of commercial fishing boats available for week-end rental. Horseback riding became a fad for some of the North Americans, while the national sport of soccer was always on tap. Playing on the local university field we attempted to introduce soft ball, but it did not take hold, despite the excellence of our exhibitions. The almost never-ending growing season was a delight to amateur gardeners who achieved almost unbelievable results. The bad roads prohibited long driving trips, but hundreds of choice picnic spots and wonderful scenery could be had very few kilometers from town. It was never a question of trying to fill non-working moments, but rather of choosing just what one wanted to do most.

Presently Chile's future presents a bit of a question mark. Natural nitrates, with which Chile supplied most of the world, lost their importance shortly after the First War. Its abundance of copper, which also played a major part in its international trade baiance, has run into competition with other recently discovered sources. Its high grade wines have not been fully publicized, but this is only a matter of time. But oil has been discovered and exploited within the past few years, and the supplies of coal and iron ore are ample to sustain its steel industry. There is almost unlimited water power available from the Andes, and there is a growing climate which can hardly be equalled anywhere in the world. The cold waters of the South Pacific teem with exportable fish. Properly integrating these resources with a comprehensive educational system and an adequate network of all-weather roads, and the future of Chile appears bright indeed.

FIRST PRIVATELY-FINANCED ATOMIC PARTS PLANT GOES INTO OPERATION

▲THE Westinghouse Electric Corp. on July 14 unveiled the world's first privately-financed factory designed to produce parts for atomic power plants. The plant is located in Cheswick, Pa. At this plant, Westinghouse has constructed also a high pressure "proving ground" designed expressly for the full-scale testing of canned motor-pumps and valves used in nuclear power plants and atomic power systems.

This new pump testing facility, or "test loop" as it is called, is believed to be the largest of its kind in the world. It is capable of testing equipment at very high pressures, temperatures, and capacities. It cost approximately $400,000.

An instrumentation laboratory has also been installed at the plant. Purpose of the laboratory is to advance the art of reactor instrumentation and control.

The Cheswick plant itself, which is part of the rapidly-growing Westinghouse atomic power division, currently has a manufacturing area of about 87,000 sq ft. It is located in Harmar Township on a 113-acre tract of land about one mile northeast of the Allegheny Valley Interchange of the Pennsylvania Turnpike. About 200 persons, including shop and office personnel, currently are employed in the operation.

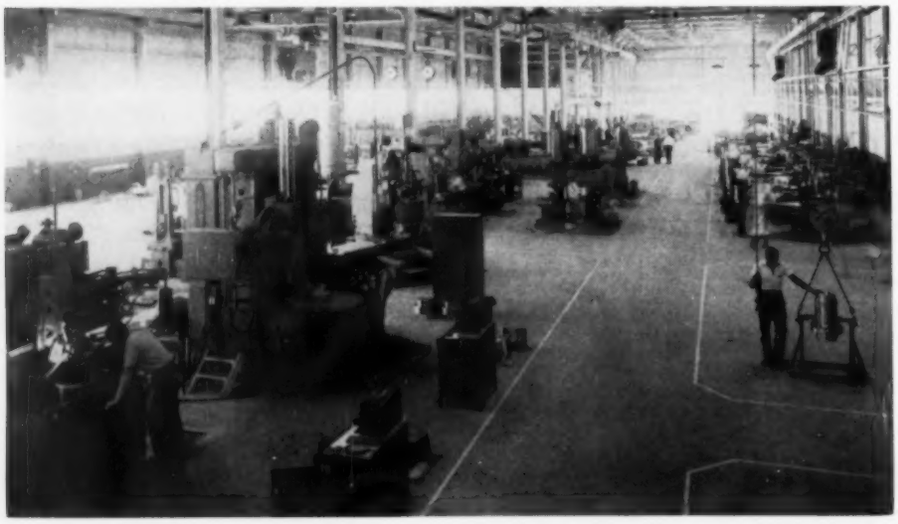

Figure 1 — Boring mills, drill presses, lathes, and other machinery are shown in this interior view of the Westinghouse atomic equipment department plant in Cheswick, Pa. One of the smaller canned motor-pumps is shown in the lower right.

The canned motor-pump — first product to be manufactured at the Cheswick plant—was developed and first built for the Atomic Energy Commission's Bettis plant, which is operated by Westinghouse, as one of the requirements in the firm's contract with the Atomic Energy Commission to build the nuclear power plant for the first atomic submarine, the U.S.S. Nautilis.

One of the problems encountered in constructing nuclear reactors involved the prevention of radio-active water leakage. Conventional pumps would not do at all. The key to a leak-proof system was the use of what is now known as the canned motor-pump.

The design for the canned motor-pump is unique in concept as the pump impeller and its electric drive motor are encased within a single pressure-tight vessel. Then, the fluid being pumped circulates throughout the motor: through its bearings, about its rotor, and around its sealed stator. The stator windings are protected from the hot fluid by jacketing the ends and outside diameter in stainless steel and then lining the inner bore with a cylinder or can of thin nickel alloy sheet, welded leak tight at each end. The outer surface of the rotor is "canned" in a similar manner and for the same reason. As is generally known, it is from these cans that the term "canned" motor-pump is derived.

Whether a canned motor-pump is large or small, its manufacture requires extreme precision. Some parts are worked to tolerances of five millionths-of-an-inch. These tolerances are checked in the engineering laboratory with extremely sensitive measuring devices: profilometers in super-fine finishes; optically ground flats and a monochromatic light source for flatness of surface.

The rotating portion of every canned motor-pump is so delicately balanced that the removal or addition of a few grains of metal—a fraction of the weight of a paper clip—would throw it out of balance.

To make certain that every motor-

Figure 2 — Canned motor-pumps such as this one are now in production. They are made with watchmaking precision from special alloy steels that resist the corrosive effects of hot, radioactive water.

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pump is leak-proof, tests are made on each component about which radioactive water passes for leaks by first creating a vacuum in the part and spraying the outside of the part with helium gas. If there are any leaks, no matter how small, the helium will be sucked inside and carried to a detector called a mass spectrometer. The detector is so sensitive that it can ferret out a helium leak of one eighth-millionths of a cubic centimeter per second.

At Cheswick, canned motor-pumps currently in production range in size from ½ hp of 5 gpm up to 300 hp or 4000 gpm. They weigh anywhere from 60 to nearly 7000 lb.

Similar, if not so critical, leakage problems arise in some industrial processes, especially in high temperature and high pressure applications. The first industrial application went into service on July 25 when the Virginia Electric Power Co. started at its Possum Point generating station the first "canned motor-pump" ever used to circulate boiler feed water in a closed-loop system.

The canned motor-pump in the Possum Point generating station circulates 4700 gpm of 605 degree F water at 1725 psi continuously, taking suction from the steam drum and pumping through the boiler back to the drum. It is driven at a constant speed of 1800 rpm by a 150-hp, 440-volt, 3-phase, 60-cycle motor.

Aside from the zero-leakage feature of the canned motor-pump—a feature of signal importance in a closed-loop feed water system—it offers other advantages. First of all, being small and light, it is extremely simple to install: all that is necessary is to lower in place and connect two services—cooling water lines and 440-volt a-c power. Secondly, the instrumentation is minimal: a cooling water flow indicator and a pump-bearing thermocouple—both are connected to light and buzzer circuits. Finally, being an hermetically-sealed unit, it can operate without an injection water bleed and since there are no external shaft seals, maintenance problems are greatly simplified.

General Electric Dedicates New Research Facility

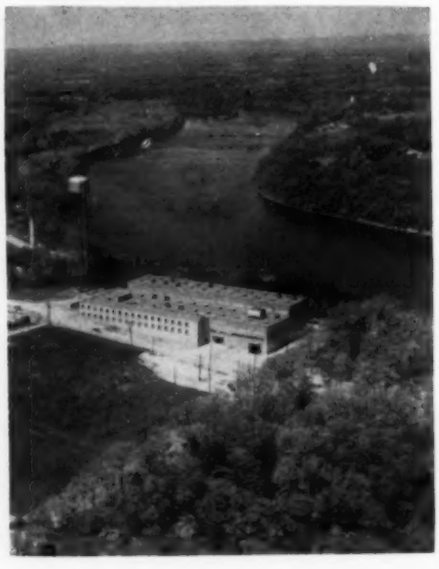
▲ THE new $5,000,000 Metals and Ceramics Building at the General Electric Research Laboratory is a facility that research men in the iron and steel industry will envy. Here, in a building 288 ft x 130 ft with an office and laboratory wing attached, is virtually a steel plant in miniature, with equipment for melting, hot-working and cold-working in both laboratory and industry size.

The foundry section contains furnaces ranging from a one-ton, top-charged arc furnace with special exhaust hood and dust-collecting system, down to a small multiple-hearth vacuum arc furnace for preparing "button-sized" melts for the laboratory. Also in use are a 50-lb gas pot furnace, induction furnaces of 15 to 300-lb capacity operated from a 3000-cycle power system, small vacuum resistance furnaces, a 600-lb vacuum arc-melting furnace of consumable electrode design.

A shot-blast unit, a pickling unit and miscellaneous auxiliary equipment completes the foundry section.

The fabrication laboratory contains an extensive layout of equipment for hot-working and cold-working. Here is a two-stand 16-10 in. reversing mill for rolling flats or rod. It is driven by a 250-hp, d-c motor which draws power from a mercury-arc rectifier. This is believed to be the first reversing mill in the United States thus powered and controlled exclusively by magnetic amplifiers. This mill is designed for abnormally high separating forces, and provisions were made in the stands for "load blocks" to measure such forces.

Figure 1 — Aerial view shows the new Metals and Ceramics Building at the General Electric Research Laboratory, located at The Knolls overlooking the Mohawk River near Schenectady, N. Y.



A Sendzimer planetary hot mill is also installed to roll strip. This unit contains two large rolls 12⅛ in. in diameter, each surrounded by 20 work rolls 2⅛ in. in diameter x 13 in. long. The mill is driven by a 350-hp induction motor. A hydraulic pusher enters the slab between the rolls.

This department also contains a two-high, 10 in. x 12-in. reversing mill, a 1250-ton extrusion press, two 2500-lb forging hammers and a 250-lb hammer. The small hammer is arranged so that forging in an inert atmosphere may be done.

Cold-working facilities include a reversing cold mill designed for either four-high or two-high operation. This unit will roll strip up to 12 in. in width at speeds up to 240 fpm. It is driven by two 50-hp, d-c motors and has two tension reels, each powered by a 60-hp, d-c motor.

There are also a Sendzimer cold mill for strip up to 8 in. wide, three smaller cold mills, six swaging machines, a small draw bench and a 100-ton press.

Extensive facilities for heat treating are also provided, including some 20 furnaces utilizing resistance heat-

BUSINESS WEEK

PAGE 27, ISSUE JUNE 4
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THE INDUSTRY'S LEADERS AGREE:

Steel Is Ready to Grow

The steel business burst through its own built-in sonic barrier last week and assured itself that the future is probably as good as it looks.

The last reservations were cast aside, appropriately, at the 63rd meeting of the American Iron & Steel Institute (picture). There, for probably the first time in 25 years, a spokesman described the industry in unreserved terms.

Steel, said Executive Vice-Pres. Max D. Howell of AISI, occupies ". . . a dynamic position among the great growth industries—along with electronics and chemicals . . . and atomic energy."

• **Bubbling**—Howell wasn't alone in such optimism. For when the steelmaking clan gathered at the Waldorf-Astoria, New York, its leadership was in a champagne mood. Short term and long term, it looked for nothing but the best.

Short term, for example, Chmn. E gene G. Grace of Bethlehem Steel to a press conference he'd be disappoint if third-quarter operations this year s below 100%. It would be hard imagine a high-placed steelmaker sa ing anything more startling than th except during an all-out war.

Then Bethlehem's president, Arthu B. Homer, weighed in with a bold new prediction of the industry's long-term growth. The trade will have to add 60-million tons of steelmaking capacity in the next 15 years, he said. At an average yearly addition of 4-million tons, that sets a new mark for the industry to shoot at.

Earlier this year (BW—May7'55, p25), former Chmn. Ben Fairless of U.S. Steel had called for 65-million tons of new capacity in the next 25 years—an annual rate of 2.4-million tons. And Chmn. Ernest T. Weir of National Steel had called for another 75-

onger the vola- een historically. all this capacity— ney (BW—May7 t part of it will in the security mar-

nding—From all this op- nagement can draw reas- steel will be a major factor capital spending.

If you were to build 4-million tons of new capacity from the ground up, you could figure on spending $300 per ton—or $1.2-billion per year. A great deal of this new capacity, though, will not be built from the ground up. This will be particularly true in the first years of the 15-year span to which Homer referred. Rather, the gain will come from the expansion or "rounding out" of existing facilities.

That, of course, is smallish way righ is adding 20 at Ind

• **Dollars**—How much will this expansion add to the capital spending stream? The answer, of course, will vary from producer to producer. There's pretty good evidence, though, that capacity to be had by "rounding out" ought to

CORHART 104 Can Increase Output of Existing Facilities

Corhart 104 Electrocast Refractory has greater hot strength — permits higher operating temperatures. It may help you produce more steel at lower cost. Write!

QUALITY ECONOMY ENDURANCE

CORHART 104 ELECTROCAST REFRACTORY

The words "Corhart" and "Electrocast" are registered Trade Marks which indicate manufacture by Corhart Refractories Company, *Incorporated*. Corhart Refractories Co., *Incorporated*, 1600 West Lee Street, Louisville 10, Kentucky, U. S. A. • Telephone: CYpress 4471

Vital Venezuelan ore speeds on HYATT ROLLER BEARINGS in 1000 ULTRA-MODERN FREIGHT CARS!

1000 tons of iron ore per hour are unloaded from ship, conveyed to car-loading bins

1000 special cars with the most modern devices were purchased by four railroads

Ore moves from Mobile to Birmingham mills on one of the fastest schedules in history

Every car has HYATT Roller Bearings to assure delay-free delivery of the vital ore

Down at the Mobile docks operated by Marine Bulk Handling Corporation, a rich, red flood of high-grade Venezuelan ore pours from a ship's hold almost daily. This is the story of how it speeds from Mobile to the Birmingham blast furnaces of United States Steel's Tennessee Coal and Iron Division.

The job is so big that four progressive railroads—the Gulf, Mobile and Ohio, the Louisville and Nashville, the St. Louis-San Francisco, and the Southern—jointly purchased a fleet of 1000 ultra-modern hopper cars specially designed for this run. One of the most important specifications was *roller bearing journal boxes*—to cut hours from running time, prevent hot-box delays, sharply reduce motive power, lubrication and inspection costs. The only question was what *make* of roller bearings to buy. And after careful comparison the choice was easy: HYATTS! All four railroads specified *free-lateral, easy-to-install* Hyatt Journal Boxes—100%!

Here's proof again that when railroads get *all* the facts about roller bearings, they're wise to choose HYATTS! Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARING JOURNAL BOXES

RUNNING MATE OF FASTER FREIGHT

Figure 2 — View in high-bay area shows at the left corner of the building in the background the one-ton, three-phase arc furnace. Also seen are a large drop forge hammer and an extrusion press (left), and the reversing rod and strip mills and industrial heating equipment on the right.

ing elements like silicon carbide, platinum, nichrome, etc. These furnaces range up to 2 ft x 2½ ft x 12 ft in size, and work at temperatures up to 1250 C.

About 35 additional furnaces—most of them with molybdenum windings — are normally used with hydrogen atmospheres, but can also be used for nitrogen or other inert gas atmospheres up to 1600 C. These furnaces cover a wide size range up to 16 in. x 24 in. x 10 ft. Other furnaces of the same type are available for temperatures up to 1950 C.

The heat treat laboratory also has a molten salt pot, a lead bath, two vacuum furnaces, and a special furnace with magnetic field apparatus.

The powders laboratory is concerned mainly with problems of ceramics, but handles metallic powders as well. It contains mullers, mills and filters for preparing powders, presses up to 75-tons capacity, muffle furnaces, glass-melting pot furnaces, drying ovens, etc.

The new building is designed with a high degree of flexibility, with holes punched through structural members and alined throughout the building to permit easy alteration. The use of mezzanine structures, similarly designed for alteration, increases the versatility of the building.

Services carried through the building include high and low pressure steam, vacuum, hot and cold water, recirculating cooling water, distilled water, hydrogen, oxygen, nitrogen, city gas, and several types of alternating and direct current at selected voltages. These services are conveniently available to any area in the building.

On the lower floor of the wing are laboratories that serve as supporting functions to the main processing groups in the building. These laboratories include a chemical analysis area, metallographic facilities, a mechanical testing area, a magnetics, dielectrics and ferroelectrics testing laboratory, and a general purpose laboratory for small scale experimental work.

The second floor of the wing is given over principally to offices.

A part of the research laboratory's $13,000,000 expansion program, this new unit will serve as a link between basic research and factory application.

Figure 3 (left) — This mill features a reversing rectifier drive controlled by a new magnetic amplifier system. The drive can reverse the mill from full speed in one direction to full speed in the other in 1½ seconds. Fast reversal enables the operator to exert much greater control over the metal-working operation than is possible with conventional drives.

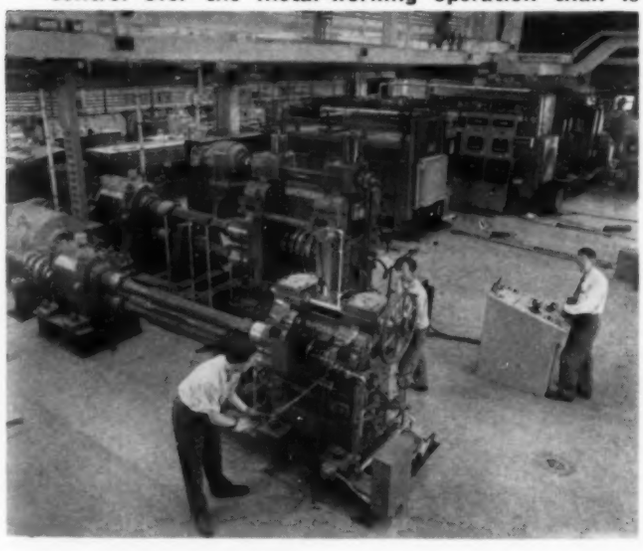
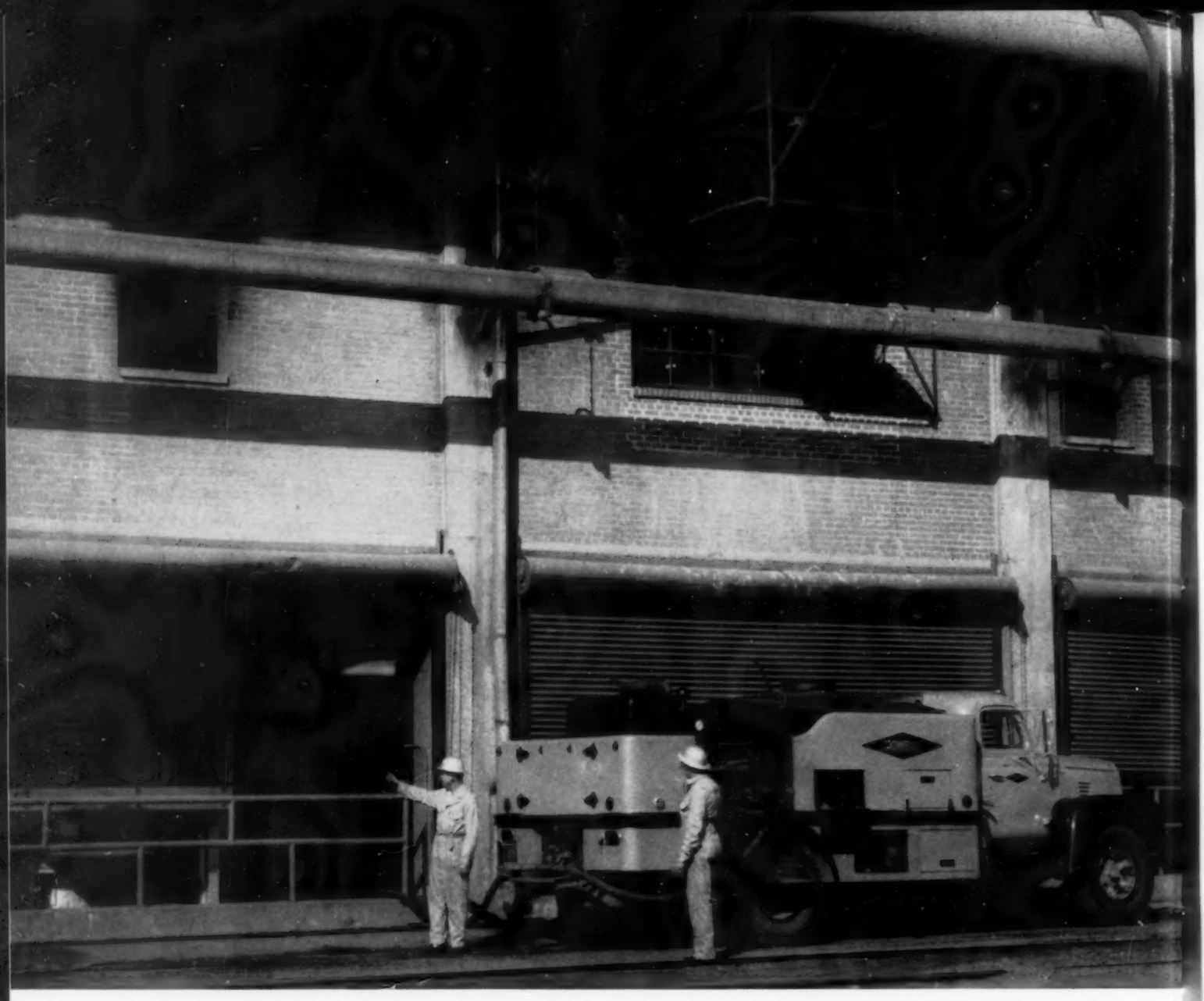


Figure 4 (right) — The planetary mill recently installed utilizes a system of rolls which permits reductions as great as 20 to 1 or about ten times that produced by conventional rolling mills.



MILL SHUTDOWN ENDED IN 3 HOURS

Shutdown ended when chemical cleaning by Dowell freed stuck valve in 54-inch gas line

Blast furnace dust in this 54-inch gas line caused a butterfly valve to stick open—forcing the shutdown of a steel plant rolling mill. An added complication was that gas flow through the line could not be interrupted. Without lessening the gas flow in the line, Dowell engineers removed the deposits chemically in just *3 hours*—permitting the mill to resume operations.

Here again, quick action by Dowell Service enabled a plant to hold costly outage to a minimum. And many times, as in this instance, Dowell engineers clean equipment without taking it out of service.

Dowell is ready to serve you any time of day or night—bringing all the equipment needed for each job into your plant. Cleaning with Dowell solvents is supplemented, where necessary, by mechanical methods—high-pressure jets and pipe line pigs.

Other steel mill equipment regularly cleaned by Dowell includes blast furnace stoves, gas washers, precipitators, open hearth checkers, boilers and condensers.

Contact the nearest Dowell office to see how Dowell chemical cleaning can help reduce costly shutdowns for you. Or write to Dowell Incorporated, Tulsa 1, Oklahoma. **Dept. H-29.**

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

July 1

▲ U. S. Steel Corp. announced their agreement with the United Steelworkers of America providing for an increase in hourly wages amounting to an average of about 15¢ per hr.

July 2

▲ U. S. Steel Corp. increased prices about 5.8 per cent or $7.35 a ton to absorb the increase in cost from their recent wage settlement.

July 4

▲ The AISI reports that operating rate of the steel industry for the week of July 4 is scheduled at 89.7 per cent of capacity. This is equivalent to 2,164,000 tons compared with 1,716,000 tons one week ago and 1,430,000 tons one year ago. Index of production for the week is 134.7.

July 5

▲ Shipments of finished steel products in May 1955 set a new record at 7,540,889 net tons in comparison with the previous record set in March 1953 which was 7,436,919 tons.

July 6

▲ The F. W. Dodge Corp. reported contract awards for future construction in the 37 states east of the Rockies set a new record in June with a grand total of $2,255,209,000 which was 30 per cent above June 1954.

▲ General Motors directors voted a 3-for-1 stock split which would bring their total common stocks to 278,698,000 shares.

▲ The Commerce Dept. decided that scrap exporters will remain free of restrictions on the total quantity of scrap they can sell abroad but will be subject to stiff licensing controls which went into effect in March.

July 8

▲ U. S. Steel Corp. announced mill prices for various grades of pig iron will be advanced $2.50 per gross ton.

▲ Alan Wood Steel Co. has purchased the steel equipment division of Penn Metal Corp. of Pennsylvania at Philadelphia. The division will operate under the trade name "Penco" and will manufacture steel lockers, cabinets and shelving.

July 11

▲ Total employment climbed for the first time to over 64,000,000 in June according to the Labor and Commerce Depts. Unemployment in June was only 200,000 above the May level.

▲ The AISI reports that operating rate of the steel industry for the week of July 11 is scheduled at 92.5 per cent of capacity. This is equivalent to 2,233,000 tons compared with 2,073,000 tons one week ago and 1,534,000 tons one year ago. Index of production for the week is 139.0.

July 12

▲ The CIO Steelworkers and A.F.L. Aluminum Workers will bargain jointly for the first time in negotiating a wage increase from ALCOA.

July 13

▲ Inland Steel Co. announced an offering of 500,000 shares of its common stock to 23,750 employees at $69.75 a share which is 10 per cent less than the average price on the New York stock exchange.

July 14

▲ Consumption of ferrous scrap during May totaled 6,425,000 gross tons in comparison with 6,239,036 gross tons the previous month according to the Mineral Industry Surveys of the U. S. Dept. of the Interior.

July 15

▲ Republic Steel Corp. reported sales for the first half of 1955 of $570,684,791 with a net income of $41,137,071 or $2.68 per common share in comparison with total sales of $432,609,292 and net income of $24,791,945 or $1.65 per common share for the first half of 1954. Sales for the second quarter were $307,411,419 with net income of $22,944,806 or $1.50 a share.

▲ On sales of $63,185,269 Allegheny Ludlum Steel Corp. declared net earnings amounting to $4,004,747 or $2.32 per common share of stock for the second quarter of 1955. These compared with total sales of $39,671,054 and earnings of $828,221 or $0.44 per share for the like period in 1954. Sales for the first six months of 1955 totaled $116,842,495 resulting in a net profit of $6,415,653 or $3.69 per common share in comparison with sales of $85,285,193, and a net profit of $1,891,671 or $1.01 in the first six months of the previous year.

July 16

▲ The Aluminum Association reported primary aluminum production in the United States totaled 255,265,003 lb in June in comparison with 262,256,314 lb in May and 241,516,343 lb in June 1954.

July 18

▲ An ICC examiner recommended a rate cut of 30 cents a gross ton on imported iron ore moving by rail from New York and Boston to areas around Youngstown, Ohio. If it goes through, the new price would be $3.01 a gross ton.

▲ Operators along the Great Lakes have boosted lake freight rates for hauling iron ore by 10¢ a ton.

▲ The AISI reports that operating rate of the steel industry for the week of July 18 is scheduled at 94.3 per cent of capacity. This is equivalent to 2,276,000 tons compared with 2,202,000 tons one week ago and 1,557,000 tons one year ago. Index of production for the week is 141.7.

▲ The ARCI announced deliveries of new domestic freight cars in June totaled 3015 in comparison with 4083 in May. Orders for 13,365 cars were placed in June increasing the backlog of cars on order as of July 1 totaling 27,102.

July 19

▲ On total sales of $157,962,512, Youngstown Sheet and Tube Co. declared a net income of $10,031,014 or $2.98 for the second quarter of 1955 in comparison with total sales of $117,600,470 and net income of $6,081,216 or $1.82 per common share for the second quarter of 1954. Sales for the first half were $297,032,213 with earnings of $18,006,502 or $5.35 a share.

July 20

▲ U. S. Steel reduced the price on cold rolled low carbon strip steel by $4 a ton today, following the raise two weeks ago of $14 a ton.

▲ Crucible Steel Co. of America declared a net income of $4,036,579 or $2.91 per share on total sales of $63,886,545 for the second quarter of 1955 in comparison with the first quarter's net earnings of

$1.59 per share. Net sales for the first half of 1955 were $114,829,465 and net income was $6,285,475 or $4.50 per share in comparison with net sales of $84,555,951, and a net income of $1,312,395 or $0.79 per share for the first half of the previous year.

▲ Crucible Steel Co. of America announced it will redeem on August 25 all its remaining outstanding 5 per cent preferred stock at a price of $110 plus accrued dividends of $0.7639 a share.

▲ The Lake Superior Iron Ore Assn. reported iron ore consumption in June totaled 7,472,578 gross tons in comparison with 7,797,744 tons consumed in May.

▲ The Government closed fiscal 1955 with a budget deficit of $4,200,000,000 or $300,000,000 less than forecast by the President last January.

▲ The F. W. Dodge Corp. reported construction contract awards in the 37 eastern states totaled around $12,000,000,000 in the first six months of 1955. This total was 30 per cent above the record reached in the first six months of 1954.

July 21

▲ The ODM was directed by the House of Representatives to continue buying domestically mined tungsten for its stockpile program. Other items included in this program are manganese, chromite, mica, asbestos, beryl, and columbium-tantalum-bearing ores and concentrates.

▲ Acme Steel Co. reported a net income of $3,395,301 or $1.71 per common share on net sales of $53,338,031 for the first half of 1955 in comparison with a net income of $1,970,149 or $0.99 per common share on net sales of $41,245,457 for the first half of 1954. Income for the second quarter was $1,851,569 or $0.93 a share on sales of $28,423,722.

July 22

▲ According to the President's Council of Economic Advisers, national production of goods and services set a record pace of $383,000,000,000 annually during the second 1955 quarter. This was $25,400,000,000 above the year-earlier rate.

▲ The Colorado Fuel and Iron Corp. declared a net income of $10,887,163 or $3.79 per common share for the fiscal year ending June 30, 1955 in comparison with a net income of $7,051,721 or $2.46 per common share in 1954's fiscal year. For the second quarter of 1955, net income was $4,900,745 or $1.72 a share.

▲ Pittsburgh Coke and Chemical Co. reported total sales and revenues of $27,983,000 with a net income of $1,650,000 or $1.51 per common share for the first six months of 1955 in comparison with total sales and revenues of $18,332,000 and net income of $376,000 or $0.17 per common share for the first six months of the previous year.

July 25

▲ A late audit shows the net worth of the Steelworkers union to be $17,626,332 at the end of 1954, an increase of $600,000 in six months.

▲ On total sales of $84,232,155, Sharon Steel Corp. declared a net income of $4,488,002 or $4.08 per common share for the first six months of 1955 in comparison with total sales of $48,540,765, net income of $644,262 or $0.58 per common share for the first six months of the previous year. Figures for the second quarter are $44,008,754; $2,554,000 or $2.05 a share.

▲ The AISI reports that operating rate of the steel industry for the week of July 25 is scheduled at 94.6 per cent of capacity. This is equivalent to 2,284,000 tons compared with 2,195,000 tons one week ago and 1,532,000 tons one year ago. Index of production for the week is 142.2.

July 26

▲ Armco Steel Corp. reported total sales for the first six months of 1955 were $329,521,667 with net earnings of $28,020,534 or $2.65 per common share in comparison with total sales for the first six months of 1954 of $267,071,172 with net earnings of $19,001,116 or $3.64 per common share. Second quarter sales were $174,748,027 with earnings of $15,331,411.

▲ According to the AISC, June bookings of fabricated structural steel amounted to 318,150 tons compared with 303,343 in May and 219,306 tons in June 1954. Shipments in June totaled 282,325 tons leaving a backlog of work ahead as of June 30 of 1,705,979 tons.

▲ Inland Steel Co. reported net sales for the first six months of 1955 totaling $315,030,610 with a net income of $23,419,842 or $4.33 per common share in comparison with net sales of $280,065,819, and net income of $19,417,669 or $3.92 per common share for the first six months of 1954. Sales for the second quarter of 1955 were $165,797,166 with income of $5,405,400 or $2.40 a share.

July 27

▲ U. S. Steel reported a net profit of $177,877,960 or $3.10 per common share on total sales of $1,968,160,985 for the first half of 1955 in comparison with a net profit of $93,851,114 or $1.56 per common share on total sales of $1,670,842,389 for the first half of the previous year. In the second quarter, sales were $1,094,833,924, earnings were $105,225,558 or $1.85 a share.

▲ Net profits of U. S. manufacturers in the first quarter of 1955 were the highest in four years with earnings at $3,300,000,000, up 29 per cent over the first quarter of 1954, according to the SEC and FTC.

July 28

▲ Jones and Laughlin Steel Corp. reported total sales for the first six months of 1955 at $331,291,000 with net income reaching $22,568,000 or $3.51 per share. This compares with last year's first six months total sales of $261,366,000, net income of $12,147,000 or $1.84 per common share. For the second quarter, sales were $179,329,000, income was $12,926,000 or $2.01 a share.

▲ Kaiser Steel Corp. has acquired coal mining and land rights in New Mexico covering 202,950 acres for $3,500,000 which should provide Kaiser Steel with sufficient coal for hundreds of years.

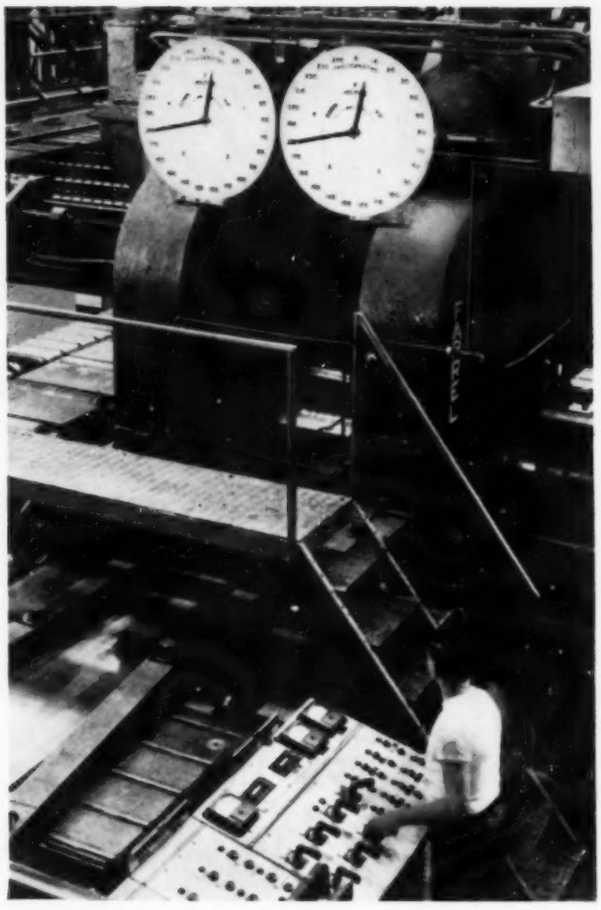
July 29

▲ Bethlehem Steel Co. reported a net profit of $82,319,324 or $8.25 per common share on total sales of $1,002,012,434 for the first six months of 1955 in comparison with a net profit of $58,558,350 or $5.77 per common share on total sales of $884,763,199 for the first six months of last year. Sales in the first quarter were $550,923,846, with earnings of $47,006,062 or $4.74 a share.

▲ National Steel Corp. reported a net income of $23,032,871 or $3.13 per common share on total sales of $308,392,251 for the six month period ending June 30, 1955 in comparison with a net income of $13,025,348 or $1.77 per common share on total sales of $251,873,398 for the six month period ending June 30, 1954. Sales for the second quarter were $157,504,750 with net income of $11,829,410 or $1.61 a share.

July 30

▲ Aluminum prices went up as a result of the 15-cent hourly wage increase granted CIO Steelworkers and A.F.L. Aluminum Workers. The increase in price is around 1¢ per lb or $20 a ton.



This 30" x 36" two-high, cold brass, breakdown mill is the largest ever designed for the nonferrous metals industry. Handles 3000 lb. bars, 25½" wide, 3" thick, and 120" long. Seven passes reduce these bars to flat metal .540" thick and 62 feet long.

NEED A ROLLING MILL FOR *SPECIALIZED PRODUCTION?*

Each mill on this page is an efficient, economical solution to a specific production problem. Each benefits from nearly 100 years of manufacturing experience and a progression of job-tested design improvements.

A Farrel® mill built to your exact needs could be equally beneficial. Just give us your requirements and one of our engineers will be glad to discuss your problems with you.

Farrel mills come in a wide range of types and sizes for rolling nonferrous rods, strips or sheets, metal foils and cold strip steel.

Send for 36-page bulletin, which describes in detail Farrel's broad line of rolling mills, gear drives, pinion stands, and special handling equipment.

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Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
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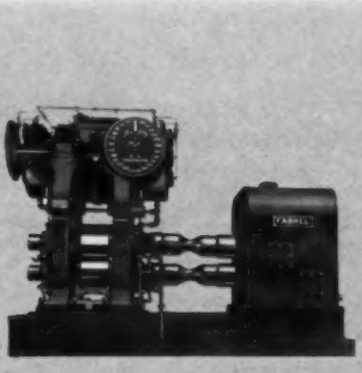
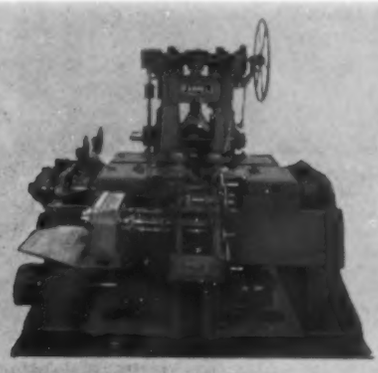


10" x 10" mill specially designed for close gauge control in continuous, high-speed, cold-rolling of high-carbon strip steel. High-powered screwdown permits gauge adjustment under full load.

Designed specifically for increasing aluminum foil production, this mill has 9" x 46" work rolls and 21" back-up rolls. Speed of operation can be varied to meet production requirements.



22" mill for cold-rolling commutator bars. Straightener and roll edger designed into assembly so bars of commonly used size can be straightened, edged and cold-rolled in one continuous operation under precise dimensional control.

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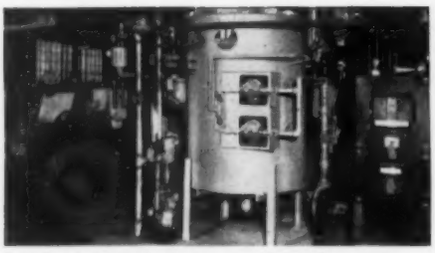
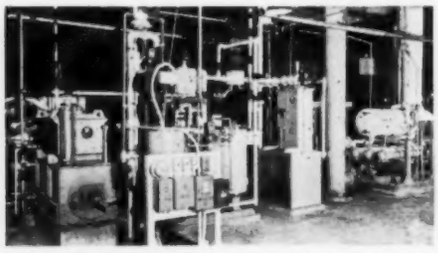
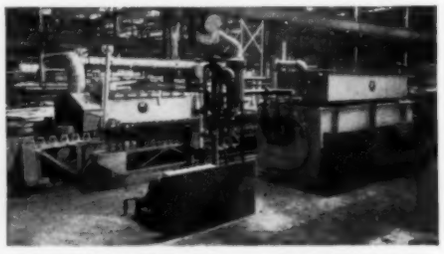


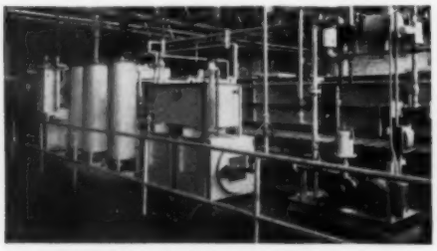
This 3000 cfh endothermic type atmosphere generator is heated by natural gas. It produces atmospheres for scale-free and non-decarb hardening small parts continuously, in an EF gas fired radiant tube chain belt conveyor furnace.



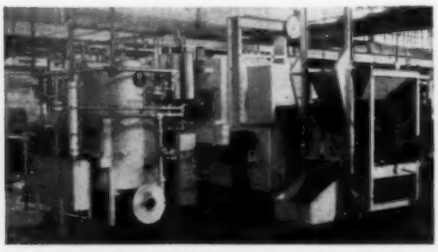
EF special dry, high nitrogen atmosphere equipment consisting of an exothermic generator, a CO_2 removal unit, a refrigerator type dehydrator, and a dryer for producing a dry, high nitrogen gas with low H_2 content suitable for bright annealing steel and non-ferrous products.



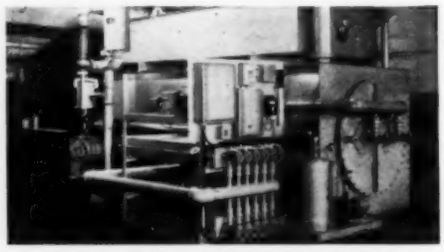
This EF 12,000 cfh lean ratio exothermic horizontal water cooled type generator provides the special atmosphere for the EF gas fired continuous furnace shown in the background. This installation is used for bright annealing copper tubing both in coils and straight lengths.



A lean ratio EF exothermic gas generator, with desulphurizers and refrigerator, produces the special atmospheres for the EF continuous bright annealing furnace shown in background. This installation is in a large copper and brass wire mill.



This EF special atmosphere generator has special adaptor to enable it to operate either as an exothermic or endothermic generator. It is used in connection with the continuous EF bolt hardening furnace at right, for scale free hardening or for carbon restoration.



EF kerosene exothermic generators are available in various sizes and types for areas where gaseous fuels are not obtainable. This 12,000 cfh kerosene unit is shown undergoing our regular factory tests, prior to shipment to South America for use with EF furnaces for bright annealing copper and scale-free annealing brass.

● EF engineers pioneered the development and the use of endothermic, exothermic and other low cost special atmosphere treatments for bright annealing ferrous and non-ferrous strip, tubing, wire and other products; for scale-free hardening, carbon restoration, decarburization and other treatments. The complete line includes endothermic and exothermic generators, ammonia dissociators, refrigerators, dryers, desulphurizers, gas scrubbing units, CO_2 removal units and other needed equipment. Automatically controlled. For the utmost in efficient, low cost operation consult EF engineers, headquarters for special atmosphere equipment — and heat treating furnaces.

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positions 65,000 lb. wind-up reel to deliver straight coils

This straight coil and others just like it are produced without exception on the continuous galvanizing line at the Wheeling Steel Plant in Martins Ferry, Ohio. Even though the coil and reel together weigh 65,000 lbs., the Askania Edge Position Control reacts with sufficient speed, precision and thrust to maintain the edge position within a tolerance of plus or minus .0156 of an inch.

Simple, dependable, powerful and accurate, the Askania control is the solution to the problem that previously defied control. Any mechanic can maintain it; it is self-lubricated; it incorporates only one moving part. It delivers power instantly in almost unlimited amounts for heavy loads. It is low in cost and built to take all the abuse that continuous operation in hard service can give.

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For full details, write for Bulletin 161 and 139.

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LIMA, OHIO • Plants at Lima and Springfield, Ohio

Industry News...

INTERLAKE IRON CORP. ANNOUNCES NEW HIGHS IN PRODUCTION AND SALES FOR FIRST HALF

▲ The nation's leading independent pig iron producer, Interlake Iron Corp., set new high records for production, sales and net income in the first half of 1955, President Ronald W. Thompson announced. Net sales and other revenues were $48,255,968, and net income was $4,002,786, equal to $2.05 per common share. In the first half of last year, sales and revenues were $31,657,765, and net income was $1,229,881, or $.63 per share.

On June 7, the first shipment of iron ore was made from the Tioga No. 2 mine of Western Mining Co., in which Interlake owns a 50 per cent interest. The property includes a plant for the beneficiation of low-grade iron ore, and according to President Thompson represents an important step in the company's program to assure adequate ore reserves for the future.

Work was started during the second quarter on a new battery of coke ovens and related facilities at Interlake's Chicago plant. This project involves the expenditure of some $10,000,000 and is scheduled for completion next summer.

TO BUILD REFRACTORIES PLANT IN LIMA, PERU

▲ Harbison-Walker Refractories Co. recently purchased a tract of land in Lima, Peru on which a refractories plant for the production of fireclay, silica and basic refractories will be constructed immediately. Associated with Harbison-Walker in the project are Cerro de Pasco Corp. of New York and Lima, and Miguel Dammert Muelle of San Isidro, Peru. Harbison will have the majority interest in the new company which will be known as Refractarios Peruanos, S.A., and will supply the supervisory and technical management. The plant will be operated largely by Peruvian personnel.

The new operation will take care of all requirements of Peruvian industry, including the smelting of copper and other metals, and the manufacture of Portland cement, steel, and glass.

KAISER STEEL ACQUIRES COAL-BEARING PROPERTY

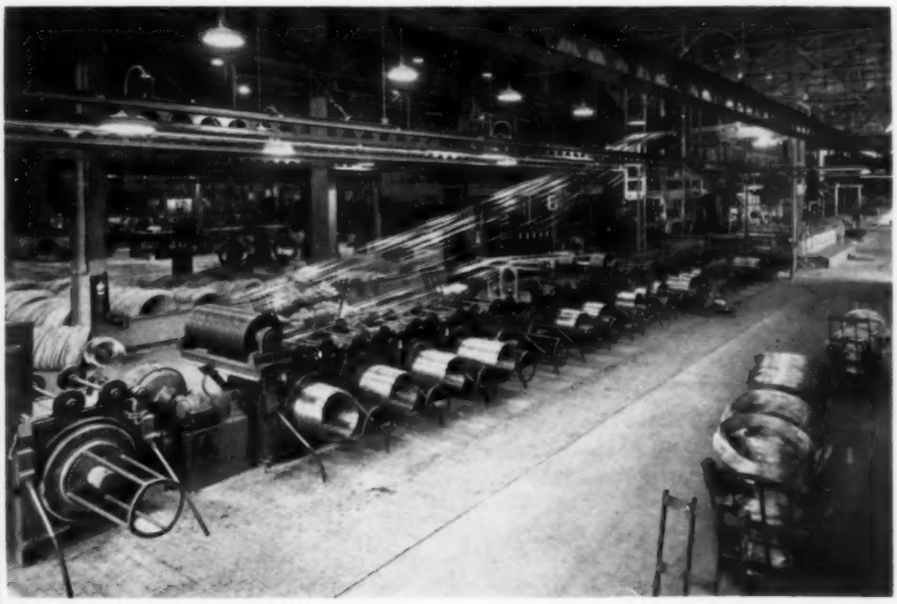
▲ Kaiser Steel Corp. has purchased all the real estate and mining properties of the St. Louis, Rocky Mountain and Pacific Co. in Raton, N. M.

The acquisition involves title to 202,950 acres of coal-bearing land and coal mining rights on an additional 326,854 acres, for a purchase price of $3,500,000. According to mining engineering reports furnished to Kaiser Steel, this property comprises the largest single area of coal land ownership in the United States. The reserves are estimated to be sufficient to supply Kaiser Steel's requirements at the present rate of consumption for many hundreds of years.

Purchase of the new coal lands will not affect operation of Kaiser Steel's coal mine at Sunnyside, Utah. Reserves of coal at the Sunnyside operation are sufficient for the company's present rate of operation for more than 70 years and will remain the main source of coal for the steel mill at Fontana.

WIRE GALVANIZING UNIT AT BETHLEHEM PACIFIC

Capable of handling up to 40 strands of wire at one time, this wire galvanizing unit went into production recently at the Los Angeles, Calif. plant of Bethlehem Pacific Coast Steel Corp. The new line, adjacent to the wire mill, is 365 ft long, and offers a wide production versatility. Wires ranging in size from 5/16 in. to 18 gage can be galvanized. By using various combinations on the take-up frames, various wire sizes can be galvanized at the same time.



AEC APPROVES RADIATION STANDARDS REGULATION

▲ The Atomic Energy Commission has approved a proposed regulation establishing standards for protection of personnel and the public against radiation hazards. The regulation will apply to all persons who receive, possess, use, or transfer source material, special nuclear material, or by-product material under a general or specific license. The proposed regulation will be published in the Federal Register, giving official notice of proposed rule making, and a thirty-day period will follow during which the public may submit written suggestions and comments.

The proposed regulation establishes maximum permissible limits on exposures to external radiation and concentrations of radioactive material, and maximum permissible levels of radiation in areas access to which is not controlled by the licensee. It also

HERE'S THE USG® BRUSH THAT DOES AN OUTSTANDING JOB ON ALL YOUR MILL MOTORS

When you replace the brushes on your mill motors, you can get the best results with USG Grade 135 Brush with Statite®. For brushes that give superb results in other applications, see below. Write for your copy of the complete USG Brush catalog today.

A typical USG Grade 135 Mill Motor Brush with Statite*

USG Grade 1658 Brush for tin line collector rolls

USG Grade 223 Brush for DC crane motors with Statite*

USG Grade AH897 Brush for Welding generators with Statite*

USG Grade 550 for AC Crane Motor Rings

*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

203

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

establishes controls over the release of radioactive material from licensed facilities. The standards incorporated in the proposed regulation are based on recommendations made by the National Committee on Radiation Protection. On the basis of present scientific knowledge and experience the permissible levels of exposure and concentration and other requirements will provide a substantial margin of safety for personnel and the public.

INLAND STEEL AWARDS CONTRACT TO KOPPERS

▲ A contract for construction of a new battery of 87 coke ovens has been awarded by Inland Steel Co. to Koppers Co., Inc. The project is part of a multi-million dollar construction program for the steel company's Indiana Harbor Works, and will increase the plant's coke-making capacity by 21 per cent.

Koppers will also design and build additional coal chemical facilities and the expansion of equipment for handling coal and coke.

The new coke battery will be the seventh at the plant and raise its total capacity from 2,143,400 tons of coke a year to 2,598,000.

Engineering work has been started and the construction schedule calls for completion in a year.

FORMS INDUSTRIAL HEATING DIVISION

▲ Formation of an industrial heating division in Westinghouse Electric Corp. has been announced by John K. Hodnette, vice president and general manager of industrial products.

The new organizational unit will combine the functions of the company's induction heating activities, located at Baltimore, Md., and the industrial heating department, located at Meadville, Pa. Headquarters of the new division will be at Meadville. L. R. Hague has been appointed manager of the industrial heating division.

Products to be manufactured within the division include electric and gas industrial furnaces, protective atmosphere equipment, heaters and thermostats at Meadville, and induction heating apparatus at Baltimore.

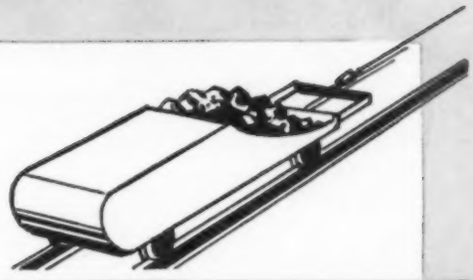
Mr. Hague stated that the new organizational arrangement "will permit more efficient technical and order service to our customers. Many rap-

If you have

BULK MATERIALS

that are.....

hoisted .....



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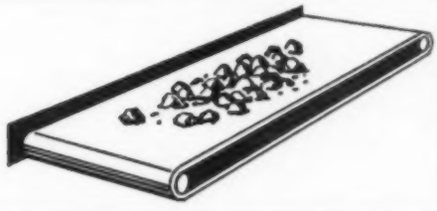

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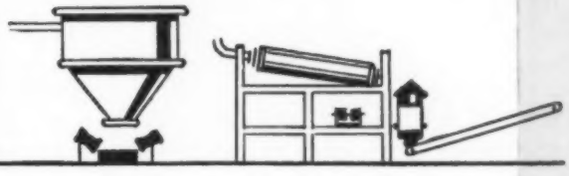

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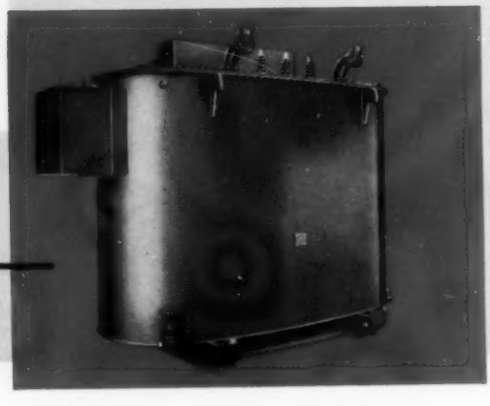
100 kva... 25,000 kva...or higher...

Pennsylvania can build a Furnace Transformer for any size electric furnace

25,000 Kva Furnace Transformer, Low Voltage Side. 3 Phase, 60 Cycles, Water-cooled. High Voltage: 13800 volts. Low Voltage: 430 to 290 volts.



External view of transformer. Compartment on left houses motor-operated tap changer.

The successful operation of Pennsylvania Furnace Transformers and their industry-wide acceptance indicate that Pennsylvania engineers fully understand the application of furnace transformers to electric furnaces.

For example, in 1936 Pennsylvania introduced a new type of helical winding in the low voltage coils of a 2500 Kva furnace transformer. Since then, the same principles of coil design have been incorporated into Pennsylvania furnace transformers totaling over 1¼ million Kva. In all the intervening years, there has *never* been a low voltage winding breakdown on any of these furnace transformers.

Because its engineering is basically and fundamentally correct, Pennsylvania can build furnace transformers for any size electric furnace now being manufactured or being contemplated for future construction.

PENNSYLVANIA TRANSFORMER COMPANY

A McGraw Electric Company Division

CANONSBURG • PENNSYLVANIA

idly expanding industrial firms have need for both resistance and induction heating equipment as well as atmosphere generators. Responsibility for the engineering, manufacture and sale of this apparatus is now consolidated in this new division."

ANNOUNCES PURCHASE OF KELLEY ISLAND CO.

▲ Basic Refractories, Inc. has purchased the Kelley Island Co. of Cleveland, Ohio. The purchase includes Kelley Island plants in White Rock and Gibsonburg, Ohio, and Buffalo, N. Y., together with related dolomite deposits, business, inventories, company name, patents and trademarks.

The Kelley Island properties and business was obtained primarily in order to extend Basic Refractories' activities in dolomite products into the building industry. The properties will be operated as a separate division under its present management which consists of F. J. Collins, president, J. W. Rockwood, vice president and E. J. Evans, secretary and treasurer.

METAL & THERMIT CORP. EXPANDS FACILITIES

▲ A combined general office, research and distribution center representing a total investment of over $2,000,000 will be established in Rahway, N. J., by Metal & Thermit Corp.

Completion of the new facilities is scheduled for April, 1956. At that time the company's executive offices will also be moved to new quarters at 100 Park Avenue, New York City. These offices will be occupied by the firm's senior officers, sales and production executives, technical and executive advisory staff and New York district sales personnel.

The new center at Rahway will include a general office building, a distribution warehouse and a central steam plant as well as the company's existing research facility which is being expanded.

CHAS. TAYLOR SONS CO. TO ENLARGE KY. PLANT

▲ The Chas. Taylor Sons Co., a subsidiary of National Lead Co., has announced plans for a major expansion and improvement of its Taylor, Ky., plant. Production capacity of the plant will be increased about 35 per cent by the installation of new equipment. Work will be started immediately on installation of an additional tunnel kiln, continuous dryers, and new grinding, screening and batching equipment.

The project will be completed in 1956 and will result in improved quality control, and shorter delivery time, in addition to increasing production of bonded mullite and zircon refractories.

The plant, which is located across the Ohio River from Portsmouth, Ohio, was constructed in 1902 to produce fireclay refractories from local clays. In 1926 the company began production of sillimanite, or mullite bonded super refractories and in 1933 added zircon (zirconium silicate) refractories to its line. The manufacture of fireclay refractories was discontinued in 1944 so that all facilities could be devoted to the exclusive production of special high temperature refractories.

TO BUILD NEW BATTERY AT INDIANA HARBOR

▲ A new battery of 75 coke ovens will be constructed at the Indiana Harbor Works of the Youngstown Sheet and Tube Co. The battery is expected to be in operation by September, 1956.

This is the third large construction project for the Indiana Harbor Works that has been announced since last May by the Youngstown Sheet and Tube Co. The other two—a seamless tube mill and additional tin plating facilities—are already under construction. When they go into operation, these two mills could require as many as 800 additional Youngstown employees. The new coke plant will require about 65 employees.

The new battery will be the fourth one at the Indiana Harbor Works and will be located adjacent to the number three battery which went into operation in November of 1952. It will feature underjet-fired combination ovens with additional by-products and benzol equipment and improvements to the existing coal and coke handling equipment.

The number four battery, which will be built by the Engineering and Construction Division of Koppers

(*Please turn to page 170*)

Don't junk your old planer just because it rumbles along like a freight train. Now is the time to have your outdated machine tools returned to their original performance levels through Simmons Engineered Rebuilding—at half the cost of new equipment.

Engineered Rebuilding by Simmons *unconditionally guarantees* that your machine tools will equal or exceed manufacturers' original specifications.

And, through modernization, Simmons is adapting old machines to high-speed, high-precision production that was unheard of when the tools were new.

Today: look into the important economies in production, maintenance, and liberal tax allowances available when you turn the old machines in your plant into precision equipment for today's production!

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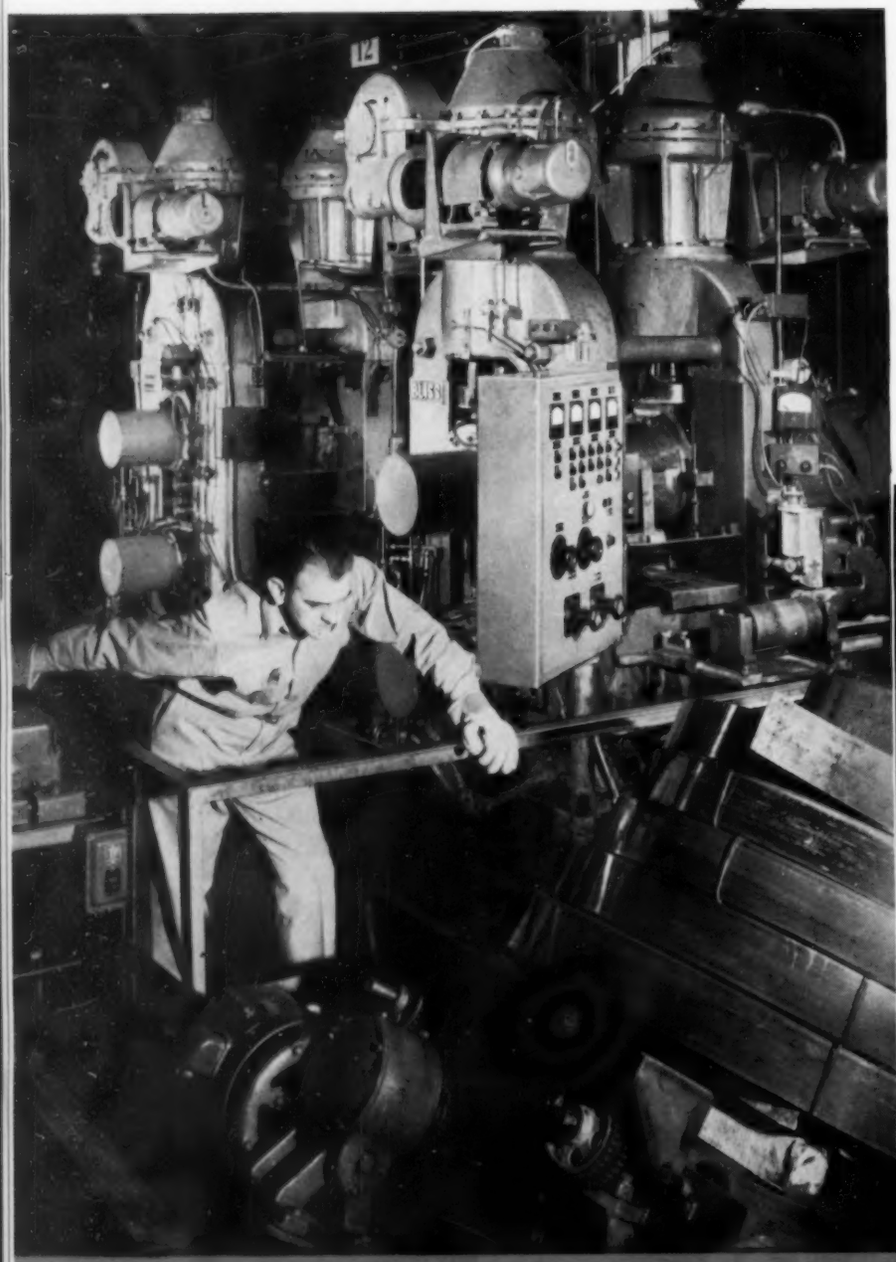
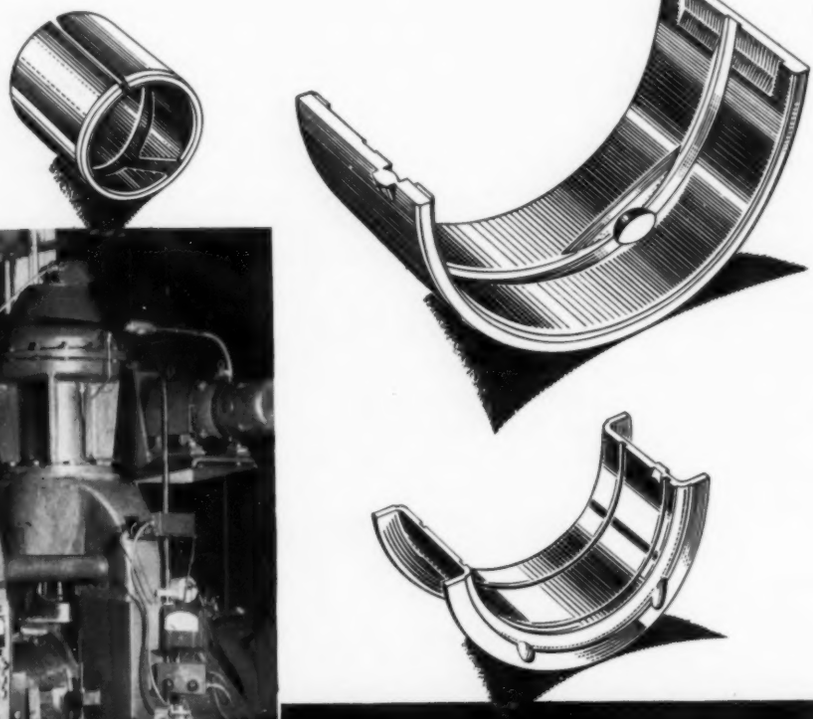
1712 N. Broadway, Albany 1, N. Y.

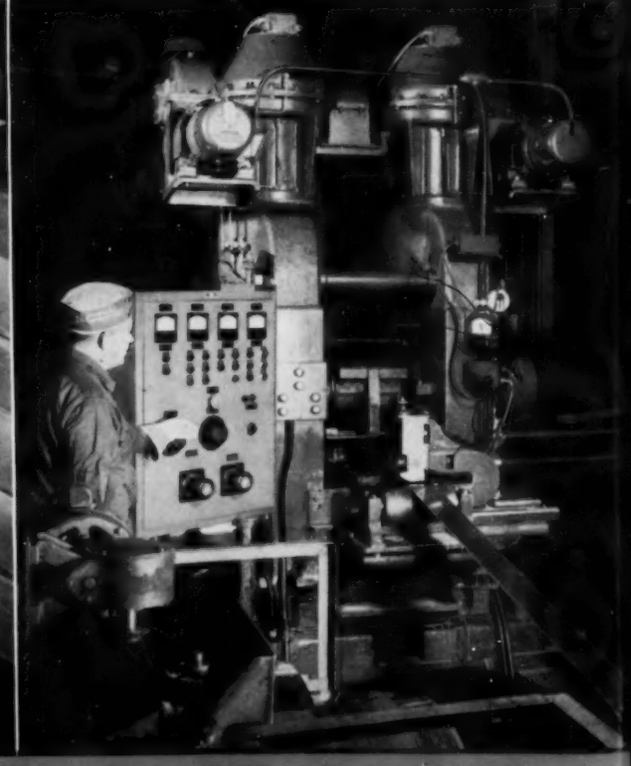
Unconditional guarantee... our standard since 1910

World's largest sleeve bearing producer relies on

BLISS MILLS AND PRESSES







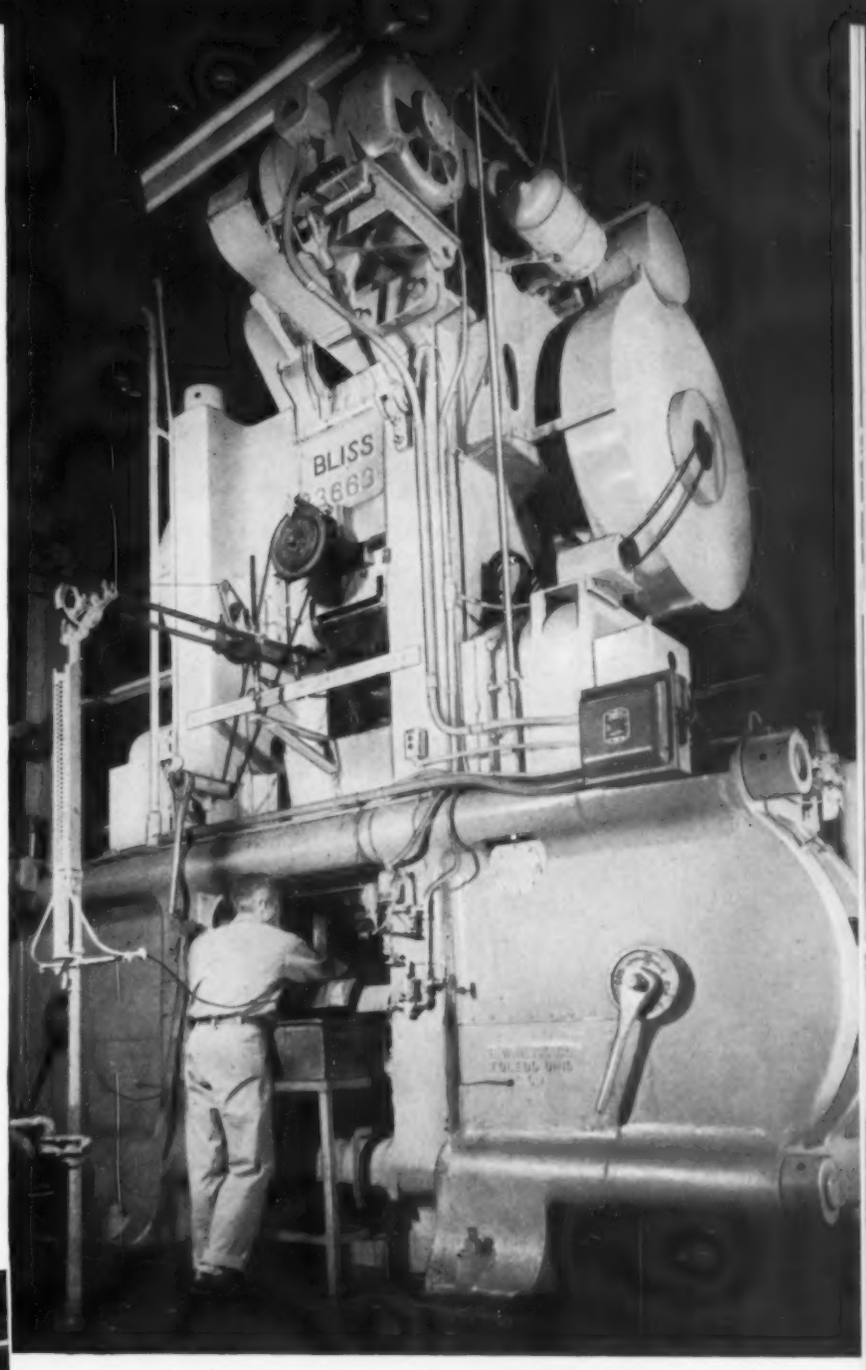
From 3000 to 3500 pounds per hour of steel-backed copper-alloy strip pass through this Bliss mill—a four-high two-stand 5¾" and 16" x 12" (a similar Bliss mill is in operation at Cleveland Graphite Bronze's Caldwell, Ohio plant). Tolerances on the cold-rolled strip are held to ±0.00075. Automatic coiling equipment handles coils off the take-up mandrel.

Clevite Corporation's Cleveland Graphite Bronze Company division is the world's largest producer of sleeve-type bearings and bushings. Its Cleveland plant turns out millions of these units every month . . . every one produced with the help of Bliss equipment. All the plant's rolling mills—which reduce steel-backed copper-alloy strip to the right gages for stamping—and 98% of its presses were designed and built by Bliss. The Bliss equipment, standard at Cleveland Graphite Bronze for years, includes four single-stand two-high mills, a new two-stand four-high mill, and 106 presses.

According to the plant superintendent, "Performance of the Bliss mills and presses has been very good. We have found the Bliss press a dependable 'work horse' which can be relied on to do a job and do it well."

As you can see, Cleveland Graphite Bronze has good reasons for its practically exclusive use of Bliss mills and presses—another example of a leader in the metalworking field who has found that "Bliss is more than a name . . . it's a guarantee."

Whether your operation involves rolling or stamping, keep abreast of new Bliss developments in these fields by writing us today.



Blanks that have been preformed on Bliss inclinable presses are fed individually into the coining die of this unusual Bliss three-slide knuckle joint press. The main slide closes first, performing the first operation. During the dwell period of the vertical slide the two side slides close, performing the two subsequent operations. Trimming and finishing are the only remaining production steps. Tolerances are held to 0.002–0.003".

A battery of Bliss high-production presses stamp out shapes with machine-gun speed, a short-stroke operation with progressive dies.

BLISS
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is more than a name . . . it's a guarantee

E. W. BLISS COMPANY, Canton, Ohio

PRESSES, ROLLING MILLS, SPECIAL MACHINERY

Rolling Mill Division: Salem, Ohio
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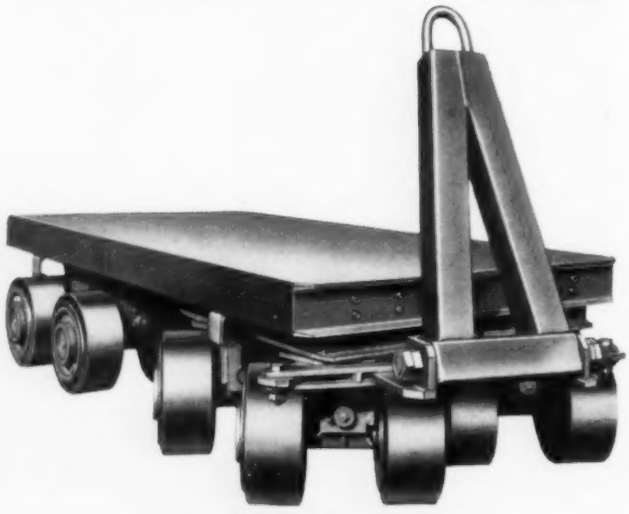
U. S. Plants in Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; San Jose, California; Midland and Pittsburgh, Pa. *Branch Offices in* Burbank, Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Pittsburgh, Philadelphia, Rochester, San Jose, Toledo, Washington, D. C.; and Toronto, Canada; E. W. Bliss (England) Ltd., Derby; E. W. Bliss Co. (Paris), France.
Other representatives throughout the world.

Handle heavy loads safely



Phillips Heavy Duty Trailers

Phillips heavy-duty trailers are designed to safely and economically haul hot metal, ingots, slabs, plate, coils, bar stock, pipe, scrap and other products requiring in-plant handling.

Built in load-handling capacities from 6000 to 250,000 lbs., the Phillips trailers feature such advantages as front or front and rear axle fifth wheels for better steering, articulated axles, synchronized steering, Timken wheel bearings, solid or pneumatic tires, and 4, 8, or 16-wheel models.

They can be used singly or in tandem, the length of trains being limited only by the tow tractor. For good load stability, good roadability, safety, peak operating performance, and low initial cost with a minimum of maintenance, specify Phillips trailers.

SALEM-BROSIUS, INC.

11 Arch Street • Carnegie, Pa.

PHILLIPS MATERIALS-HANDLING EQUIPMENT

Manufacturers Since 1863

(Continued from page 167)

Co., Inc., will convert approximately 1800 tons of coal into 1250 tons of coke daily.

PLAN STEEL PLANT FOR OAKLEY, CALIF.

▲ Plans are under way for construction of a $131,000,000 steel plant in Oakley, Calif. The plant would be built by the newly-organized Western Empire Steel Corp. President is B. J. Klarman, who has set up temporary headquarters in the East.

Western Empire now has no plants, but has an option on 2000 acres of land along the Santa Fe Railroad in Oakley, near San Francisco.

INSTALLS NEW 24-IN. MILL AND OPEN HEARTH

▲ Oklahoma City Steel Rolling Mills, Inc., has installed a new 35-ton open hearth furnace and a new 24-in. continuous mill.

A successor to Hoster Steel Mills, the firm was formed and opened in November, 1954.

An increase in production of bars, angles, small shapes and specialty items from present capacity of 600 tons a month to 1000 tons a month is expected.

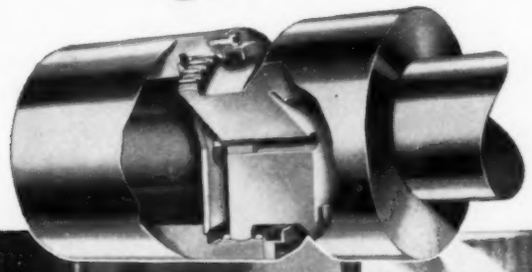
Future Meetings

▲ The first Production Engineering Show, a new series of annual expositions which will feature equipment for automation and production in all types of industries, will be held at the Navy Pier, Chicago, Ill., September 6-16, 1955. The exposition will coincide with the Machine Tool Show, which will be held at Chicago's International Amphitheatre.

▲ The Instrument Society of America's 10th Annual Instrument-Automation Conference and Exhibit will be held at the Shrine Exposition Hall and Auditorium, Los Angeles, Calif., September 12-16, 1955.

▲ The 1955 annual meeting of the Society for Experimental Stress Analysis will be held November 16, 17, 18, at the Hotel Sheraton, Chicago, Ill.

TROUBLED WITH "SLIPPER-TYPE" COUPLING FAILURES?
CONVERT TO
Amerigear® SPINDLE ROLL DRIVE COUPLINGS



. . . RUN LONGER WITHOUT MAINTENANCE

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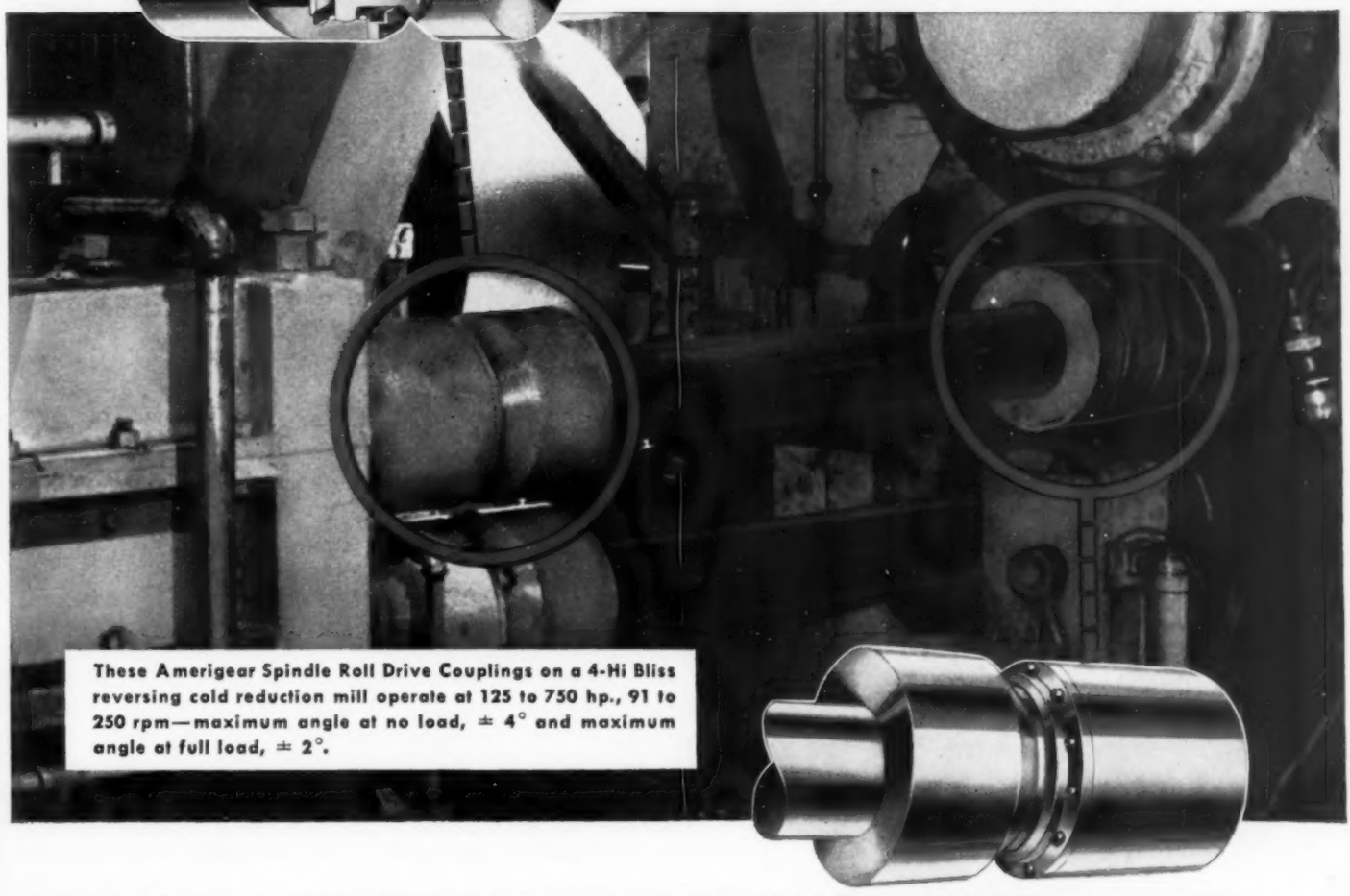

These Amerigear Spindle Roll Drive Couplings on a 4-Hi Bliss reversing cold reduction mill operate at 125 to 750 hp., 91 to 250 rpm—maximum angle at no load, ± 4° and maximum angle at full load, ± 2°.

• HERE'S THE ANSWER TO YOUR HIGH MISALIGNMENT PROBLEMS . . .

Amerigear's Fully-Crowned Tooth Form concentrates the load towards the center of the tooth, eliminates tooth end and tip loading. This permits an extremely high degree of angular and lateral misalignment—up to ± 9° per engagement—with no wear or loss of power.

And By Accommodating For Roll Wear and varying distances between roll centers, Amerigear Spindle Roll Drive Couplings keep your maintenance expenses to a minimum. That's because they're precision-manufactured to transmit power to the rolls smoothly and continuously . . . even after repeated roll grinding . . . *without maintenance.*

Downtime Goes Down, Too because engaging roll end teeth are specially designed for quick assembly and disassembly. So the next time you're in need of flexible couplings for your ferrous or non-ferrous rolling mills, convert to Amerigear — a highly engineered solution to your every high misalignment problem.

Amerigear Engineers are ready to help you design improved operating efficiency into heavy presses, slitters, cranes, reels or other steel mill equipment. Write for Catalog 501 and Bulletin 1052, or attach coupon below to your letterhead.

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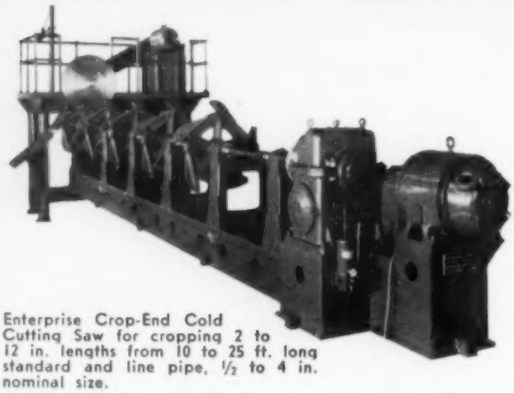
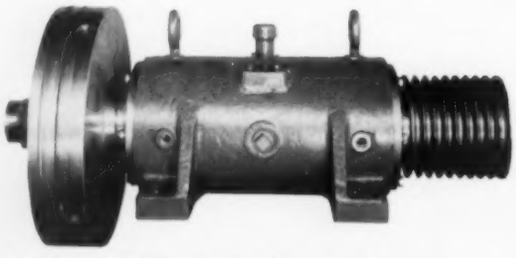
AN Enterprise MILL TYPE FRICTION SAW

In Operation at NATIONAL TUBE DIVISION UNITED STATES STEEL COMPANY FAIRLESS HILLS, PENNA.



Enterprise Crop-End Cold Cutting Saw for cropping 2 to 12 in. lengths from 10 to 25 ft. long standard and line pipe, ½ to 4 in. nominal size.



The Enterprise Friction Saw Spindle Assembly is the heart of the machine. Saw arbor is of forged steel held in special self-aligning spherical roller bearings. Assembly is dynamically balanced for 22,000 fpm sawing speed with 42 in. steel saw.

Shown here is an Enterprise Middle-cut Cold Cutting Saw, complete with five-station turret feeding mechanism, for production cutting ½ thru 4 in. (4.500 in. OD) standard pipe in standard and extra strong weights in lengths ranging from 18 to 25 ft.

ENTERPRISE Friction Saws employ the heat of friction to cut hot or cold steel sections faster than any other known method of sawing. The fast-spinning steel blade, having a large peripheral surface in comparison with the contact area, generates localized heat in the piece being cut. The resulting highly localized temperature is sufficient to weaken the contact surface allowing the saw to wipe it away without noticeably heating the blade or the remaining section. The chips removed are in the form of minute oxidized flakes thereby indicating that friction sawing is indeed a true method for sawing metals. An increasing number of applications indicate a general trend towards friction sawing in industry today.

The Enterprise Company designs and builds special friction sawing machines complete with synchronized handling tables and conveyor systems to suit particular requirements . . . If your company has a production cutting-off problem, consider friction sawing as a possibility. The Enterprise Company will gladly serve as your source for the equipment required.

Write for Bulletin 502 describing Enterprise Friction Saws.

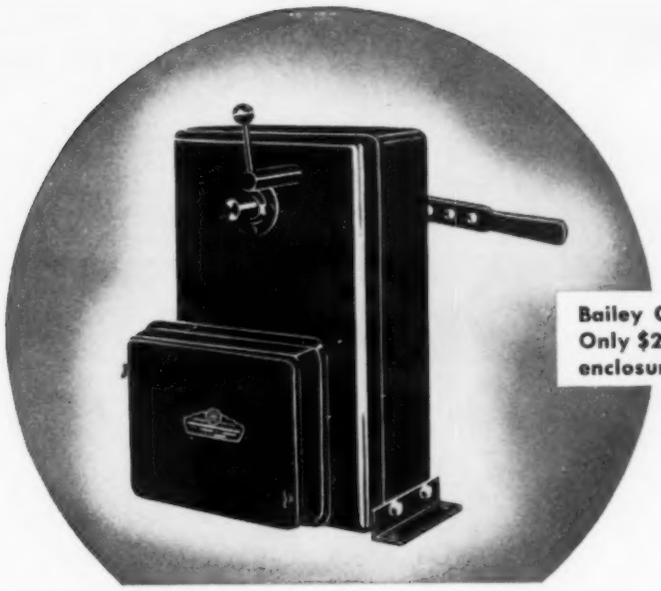
ESTABLISHED 1878

THE ENTERPRISE COMPANY

MACHINERY BUILDERS AND ENGINEERS

(SUBSIDIARY OF WM. K. STAMETS COMPANY, PITTSBURGH)

COLUMBIANA · · OHIO



Bailey Control Drive, Type AC44P Model 200. Only $210.00 F.O.B. Cleveland, complete with enclosure, positioning relay and hand operator.

Want Better Flow Characteristics from Your Regulating Devices?

This new, small, piston-operated Bailey Control Drive will improve the flow characteristics of butterfly valves, dampers, hydraulic couplings, feeders and similar regulating devices. Adjustment is simple; any desired relation between drive motion and pneumatic signal may be secured.

You can install this compact pneumatic drive power unit in any position on a column, pipe, or flat surface—and connect it to the regulating device with standard Bailey linkage, available from stock.

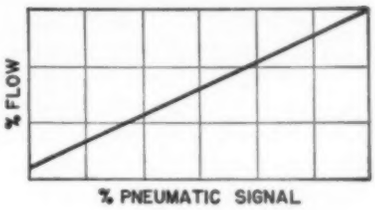
Speed (time required for full travel) is adjustable to suit your requirements. Bailey Control Drives operate on standard SAMA pneumatic signal ranges of 3 - 15 or 3 - 27 psig.

AVAILABLE FROM STOCK in 3 standard sizes

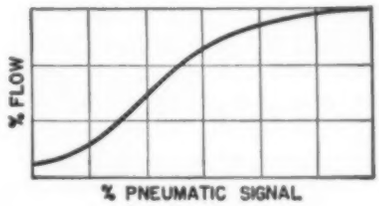
Type	Piston Dia. Inches	Piston Stroke Inches	Torque ft-lb	Max. Travel Degrees	Approx. Dimensions Inches
AC816	8	16	1500	90	13 x 27 x 51
AC68	6	8	400	90	13 x 19 x 34
AC44	4	4	75	75	10 x 11 x 19

P-28

The New Bailey Control Drive gives you THIS—



instead of THIS



BAILEY METER COMPANY

1047 IVANHOE ROAD

CLEVELAND 10, OHIO

Complete Controls for Process Plants

BAILEY METERS

Controls for

TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW LEVEL
RATIO

FOR MORE INFORMATION

FILL OUT AND MAIL

☐ I am interested in Bailey Control Drives. Mail me Spec. CA040.

☐ I am interested in Bailey Control Linkage. Mail me Spec. CA942B.

Name_____

Title & Company_____

Street & Number_____

City & Zone_____ State_____

Calumet Division, Calumet and Hecla, Inc., Calumet, Michigan

"Cities Service Heat Prover Played A Major Role In Our Expansion Program"

Miners and refiners of copper, the Calumet, Michigan Division of Calumet and Hecla, Inc., relies on two power plants to operate its many mines, reclamation plants, mills, manufacturing facilities and mine rehabilitation projects.

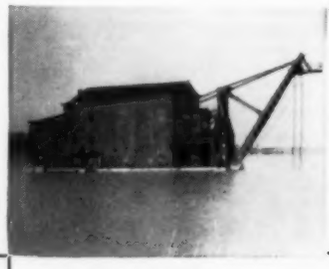
The two plants, located at Lake Linden and Hubbell, were recently brought up to date. The Lake Linden plant now has modern steam generating equipment fired with pulverized coal. The Ahmeek plant was equipped with new coal distributors for its underfeed stokers and new plastic monolithic furnace settings.

This modernization program, along with a planned preventive maintenance program which is now being put into effect, is expected to raise the KW capacity of these plants from 20 megawatts to 30 within the next few months.

The Cities Service Heat Prover has played a major role in this improvement program. It is used extensively to examine combustion conditions in the furnaces, check station instruments, and guard against air infiltration through boiler settings and duct work, thus enabling plant personnel to operate the equipment constantly at design efficiencies or better.

Says Power Superintendent, Robert Hein: "The portable Cities Service Heat Prover has proved invaluable in our operation. We are now using 150,000 tons of coal per year and operating at boiler efficiencies around 86%. By giving us a quick, accurate check on our firing conditions, the Heat Prover has been directly responsible for much of this record."

The Heat Prover is supplied and maintained free by Cities Service. For further information write Cities Service Oil Co., Sixty Wall Tower, New York 5, N. Y.



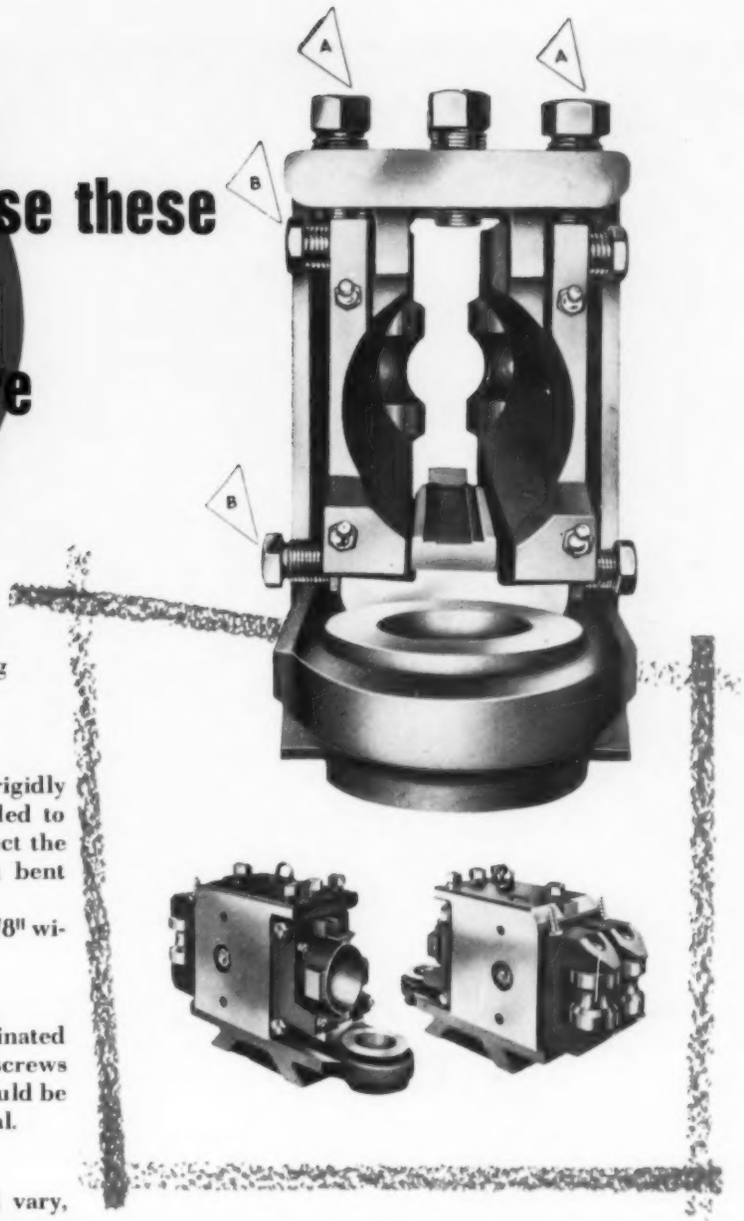
Calumet Reclamation Operation reclaims stamp sands processed years ago and dumped into lake. Further processing will extract copper. For power, dredge relies on the Calumet Division's Lake Linden Power Plant.

Taking Readings With Heat Prover has helped Calumet Division achieve 86% boiler efficiency. Will aid further in raising KW capacity from 20 to 30 megawatts. The unique instrument enables maximum heat benefits from coal.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

8 good reasons why you should use these ROLLER GUIDES in your bar or wire rod mill



The Morgårdshammar Roller Guides — patented in most countries of industrial importance — are constructed according to the following principles:

1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

2 The rollers are mounted on laminated springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted as shown by the arrows. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be plump, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.

7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and break-down oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mills. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

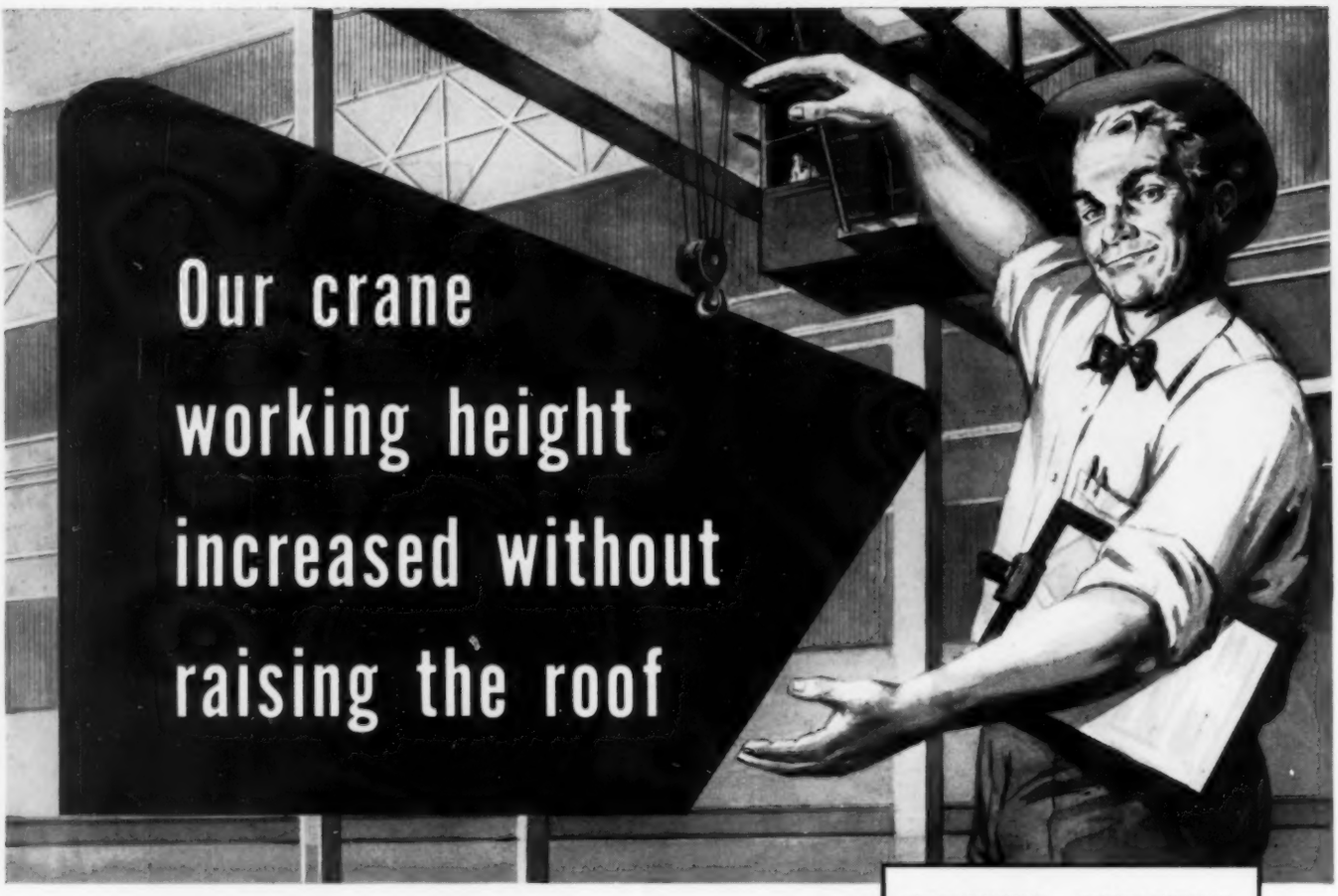
P.S. Practically speaking, every bar and wire rod mill in Scandinavia uses roller guides of our design.

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK VERKSTADS AB • MORGÅRDSHAMMAR • SWEDEN

Telegrams: Morgårdshammar, Ludvika
Telephone: Ludvika (0240) 71100

For the complete story — send for your copy of bulletin L3—1E.

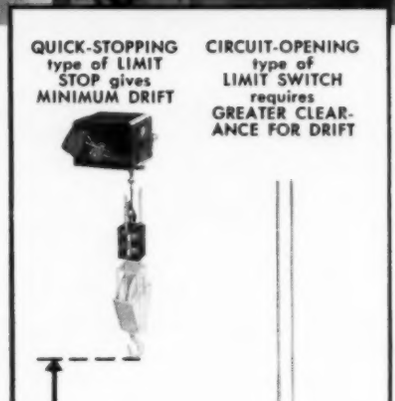


WITH EC&M YOUNGSTOWN SAFETY LIMIT STOPS

"We frequently needed more headroom on our D-c cranes. The limit stop setting couldn't be raised without sacrificing the clearance needed by the hoist-brake to safely stop the fast-moving empty hook, which hoists 2½ to 3 times faster than when hoisting full load. We had a choice . . . we could raise the roof . . . which meant deeper footings, heavier building columns and increased costs for lighting, heating and ventilating . . . OR . . . we could equip our cranes with **quick-stopping** EC&M Youngstown Safety Limit Stops."

Yes, Youngstown Hoist Limit Stops not only disconnect power from the motor but also apply **dynamic braking** to aid the hoist-brake in a **quick stop** . . . giving less drift . . . more headroom. **Safe,** too, because the tripping point does not change . . . is not affected by stretching of the hoist cables. The point at which the rising crane-hook makes contact to lift the Youngstown suspended-weight always remains the same.

For increased D-c crane headroom, **plus safety,** investigate EC&M Youngstown Safety Limit Stops.

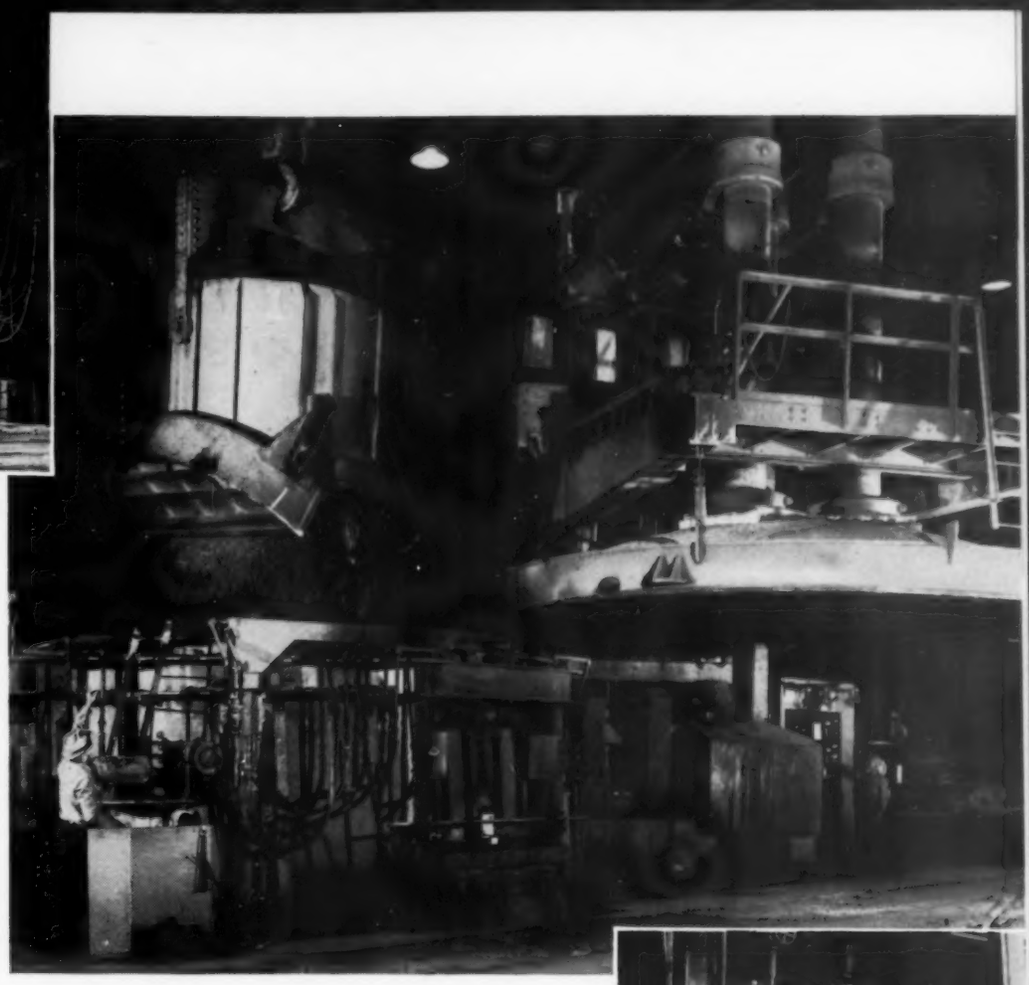

QUICK-STOPPING type of LIMIT STOP gives MINIMUM DRIFT
CIRCUIT-OPENING type of LIMIT SWITCH requires GREATER CLEARANCE FOR DRIFT
THIS SPACE SAVED

Write today for Bulletin 1032 which describes and illustrates EC&M Youngstown Limit Stops.

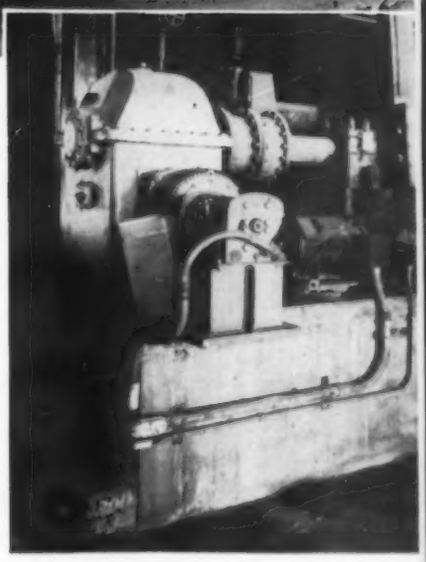
1775

YOU CAN LIFT LOADS HIGHER AND SAFER WITH EC&M YOUNGSTOWN SAFETY LIMIT STOPS

THE ELECTRIC CONTROLLER & MFG. CO.
4498 LEE ROAD ★ CLEVELAND 28, OHIO



Shown above is a 20′ diameter shell Top-Charge Heroult Furnace. At right, the same furnace is shown with swing-type roof removed for charging. Smaller picture at lower right, shows tilting mechanism for 20′ diameter Heroult.



Heroult Electric Furnaces for faster, high quality steel making - -

To keep pace with modern steel making methods . . . to produce better quality steel faster, and more economically, it will pay you to consider the addition of electric furnaces to your existing facilities.

In the light of the experience of some of the nation's most successful mills, Heroult Electric Furnaces should easily prove a big time and labor saver, *and quality up-grader* for you.

Embodying the latest in mechanical and electrical equipment, these widely used furnaces are noted for their efficient performance, and low operating and maintenance costs.

Available in sizes of shell diameter ranging from 7′0″ up to 24′6″, and with rated charge capacity of from 8000 lbs. up to 400,000 lbs. They are usually equipped with roof-moving mechanism to permit top charging. Both gantry and swing-type roof-moving mechanisms are available. Door-charging furnaces and furnaces of special design, including units equipped with austenitic steel bottoms to permit inductor stirring, can also be supplied.

We welcome an opportunity to help you select and install the Heroult Electric Furnace best suited to your particular requirements.

THIS CATALOG

contains up-to-date information on Heroult Electric Furnaces — types, sizes, capacities, rating, etc. For free copy, write to our Pittsburgh office.

AMERICAN BRIDGE DIVISION

UNITED STATES STEEL CORPORATION, GENERAL OFFICES: 525 WILLIAM PENN PLACE, PITTSBURGH, PA.

Contracting Offices in New York, Philadelphia, Chicago, San Francisco and other principal cities.

United States Steel Export Company, New York

USS

UNITED STATES STEEL

For Reliable Rectifier Operation Get

Continuous Excitation

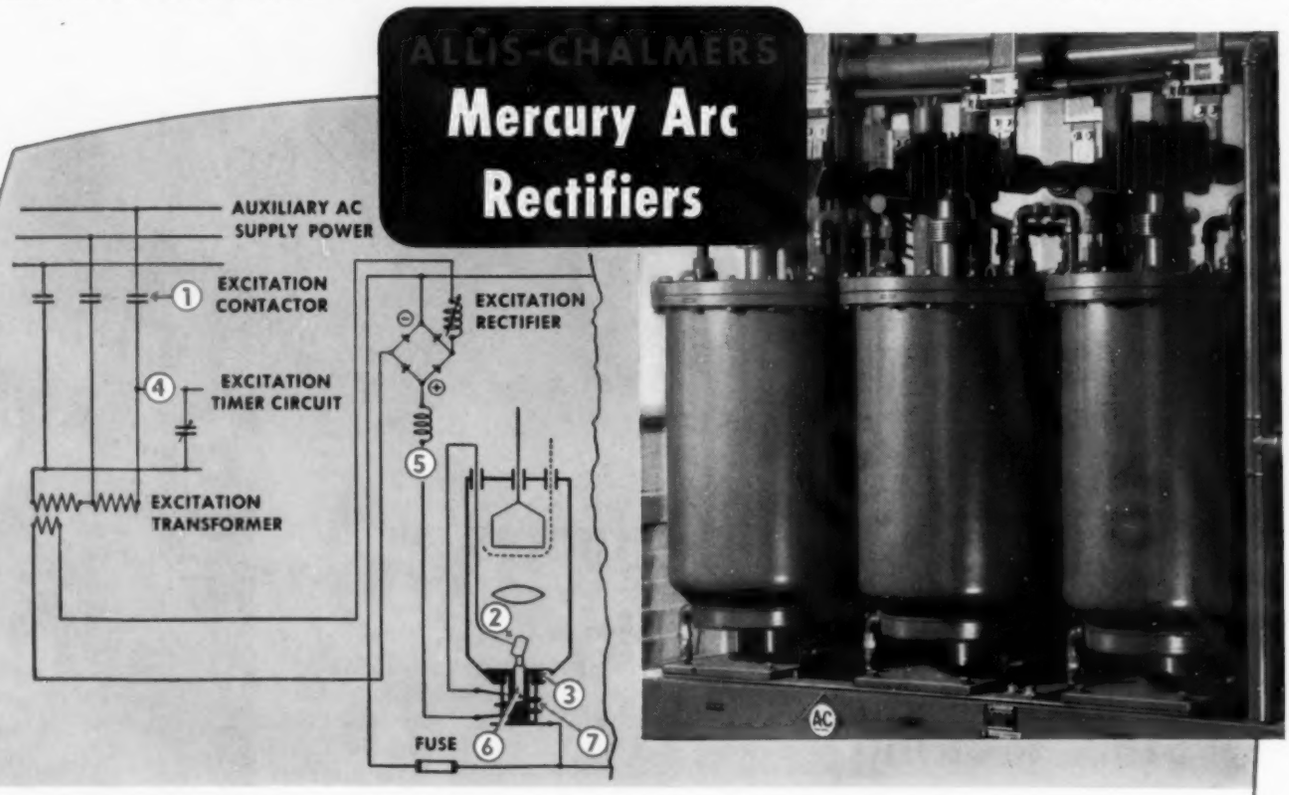
Allis-Chalmers excitron rectifiers eliminate the need for a pulse-type firing system timed for operation every cycle. Maintenance is easy because of the simplicity of design.

A small dc excitation arc is automatically ignited only once, when the unit is started, and then maintained on the mercury cathode of each rectifier tube. It offers advantages similar to a pilot light. Since it is far easier to maintain an arc than to start it, this feature makes the excitron far less likely to lose excitation during power supply disturbances than other types of rectifiers.

Get all the facts about excitron rectifiers before your next installation. Call the A-C office nearest you or write Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

Mercury Arc Rectifiers



Supply of DC Provides Key to Continuous Excitation

Direct current supplied from excitation rectifiers is the key to continuous excitation. When the excitation system is energized by means of a contactor (1), positive dc potential appears on the excitation anode (2) of each tube, negative at the cathode (3). A timer (4), through contacts of the excitation failure relay (5), is energized at the same time.

As soon as voltage is applied, current flows from the anode to the cathode through the ignition plunger (6). This current energizes the ignition coil (7) and causes the plunger to be pulled below the mercury surface. As the plunger travels down, an arc is drawn which transfers from the graphite tip of the plunger to the mercury. This current flow keeps the coil energized, maintaining a continuous arc.

If excitation failure should occur while the rectifier is carrying load, the plunger is released, floating upward in the mercury until it makes contact with the anode, then repeating the process above until the arc is re-established.

Re-establishment of the arc as outlined takes less than a second — it does not interfere with normal operation.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-4592

Personnel News...

Francis G. Kredel, superintendent of the 10-in. and 12-in. bar mills at the Cleveland steel plant of Republic Steel Corp., has been named chairman of the company's bar mill committee, succeeding **B. F. Handloser** who has retired. He will be succeeded as superintendent of the Cleveland bar mills by **E. W. Carlson** who had been assistant superintendent of the bar mills at Republic's Chicago District. Mr. Kredel first worked with Bethlehem Steel in Bethlehem and Johnstown, Pa. In 1924, he joined Corrigan-McKinney Steel Co., which subsequently became part of Republic, as foreman in the blooming mill. In 1935, he was appointed assistant superintendent of the bar mills and in 1937 was promoted to superintendent. Mr. Carlson joined Republic in 1937. He was appointed mechanical foreman in the bar mills and later assistant superintendent of maintenance. In 1950, he was named assistant superintendent of the bar mills, the position he held at the time of his present promotion. Mr. Handloser, who is 67, was chairman of Republic's bar mill committee since 1952. Prior to assuming that post, he was assigned for a year to special duties in West Orange, N. J. He had come there in 1950 from the Dilworth Porter Division of Republic in Pittsburgh, Pa., where he had been works manager. He had joined Dilworth Porter & Co., Inc. in 1909. After ten years as a works engineer, he was named assistant works manager of the company in 1919.

Stephen B. Metcalfe has been named manager of operations of the Worcester, Mass., district of American Steel and Wire Division of U. S. Steel Corp., succeeding **George A. Gleason,** who is retiring after 38 years of service with this division. Mr. Metcalfe joined the New Haven Works of American Steel and Wire in 1929, and following a training period, became a foreman in the wire rope department in 1932. Two years later he was promoted to division superintendent of the rope mill there, and in 1938 was made superintendent of Trenton Works. In January, 1942 he was appointed general superintendent in charge of both the New Haven and Trenton plants, transferring in 1945 to the Cleveland headquarters on a special engineering assignment. He returned to his post as general superintendent of New Haven and Trenton in 1948 before assuming the position of assistant district manager of operations in the Fall of 1953 with offices at Worcester.

George E. Flaccus, Jr., was named vice president—industrial relations of Jones & Laughlin Steel Corp. He replaces **V. H. Lawrence** who is retiring because of ill health. Mr. Lawrence maintains an association with J&L as consultant to the president.

Dr. Walter C. Rueckel, vice president of the Henry J. Kaiser Co., for the past four years, has been elected vice president and general manager, Engineering and Construction Division of Koppers Co., Inc. Dr. Rueckel, who left Koppers in 1951 to take the West Coast position, now returns to fill the vacancy created by the death of **George M. Carvlin.**

Harold A. Muttach has been appointed divisional superintendent, coke ovens, blast furnaces and open hearths of Granite City Steel Co. Also, **Clarence R. Mitchell** was named divisional superintendent, rolling mills, and **Russell C. Solomon,** divisional superintendent, finishing. Mr. Muttach who has been blast furnace manager, started with the company in 1923 as a powerhouse engineer, and was successively a blast furnace turn foreman, an assistant blast furnace superintendent and then superintendent, an assistant plant manager and then manager. Mr. Mitchell, formerly hot strip superintendent, came to Granite City from the Birmingham, Ala., plant of the United States Steel Corp., Tennessee Coal and Iron Division, where he was also superintendent of the hot strip mill. Prior to that, he was a roller in the cold reduction department of the Inland Steel Corp. plant in Indiana Harbor, Ind. Mr. Solomon started with Granite City in 1935. He has served as superintendent of open hearths and superintendent of operations.

Milburn V. Mills, formerly assistant general superintendent has been appointed general superintendent of Green River Steel Corp. **William H. Meyer,** formerly plant metallurgist has been appointed chief metallurgist.

Arlington A. Britton, Jr., vice president in charge of production, was elected to the board of directors of Carpenter Steel Co. **Berton H. DeLong** has retired from the Carpenter board of directors. **Dr. Carl B. Post,** head of the Metallurgical and Research Departments, was promoted to vice president in charge of

FRANCIS G. KREDEL

STEPHEN B. METCALFE

GEORGE E. FLACCUS, JR.

DR. WALTER C. RUECKEL

SYDNEY G. YOUNG

CHARLES F. SIMMERS

JOHN R. TUTTLE

ERNEST NUBER

metallurgy. Mr. Britton was elected vice president in 1953. He has been with Carpenter for 22 years, having started in 1933. After three years in inspection and five years as a production metallurgist, he was appointed assistant to the wire mill superintendent. He then became wire mill superintendent in 1945, assistant general superintendent in 1947 and general superintendent in 1948.

Sydney G. Young has been appointed sales manager for Lewis Rolls Department of the Blaw-Knox Co., succeeding **Glen McDowell.** Mr. Young joined Blaw-Knox in 1948 after ten years of experience with United States Steel Corp. operations at Gary, Ind., and at the Irvin Works, Pittsburgh, as a cold reduction supervisor.

Charles F. Simmers has been named vice president in charge of engineering of Morgan Engineering Co. He fills the vacancy created by the retirement July 1, of **William L. Ditges.** Mr. Simmers came to Morgan in 1948 after 16 years at United States Steel. Prior to his work at U. S. Steel, he was employed by United Engineering and Foundry Co. While at Morgan, Simmers has successively held several engineering posts beginning as mill design engineer, continuing to chief mill design engineer and, most recently, as assistant director of engineering.

John R. Tuttle has been named president and chairman of the board of directors of Crouse-Hinds Co. Three other executives, **William L. Hinds,** chairman of the board, **Albert F. Hills,** president, and **W. C. Blanding,** executive vice president retired from active management. They will continue as members of the board of directors.

Ernest Nuber has been promoted to general field sales manager for the Bristol Co. He joined the Bristol sales engineering organization in 1929. He was made Pacific Coast manager in 1934 and was later brought to the home office at Waterbury to become export manager. In 1948 he was promoted to the position of manager of the company's application engineering department and has held the position of sales manager since 1954.

Charles W. Lee has been appointed president of Consolidated Western Steel Division, U. S. Steel Corp. Mr. Lee, who was previously vice president and general manager of Consolidated Western, succeeds **Alden G. Roach,** who is president of Columbia-Geneva Steel Division.

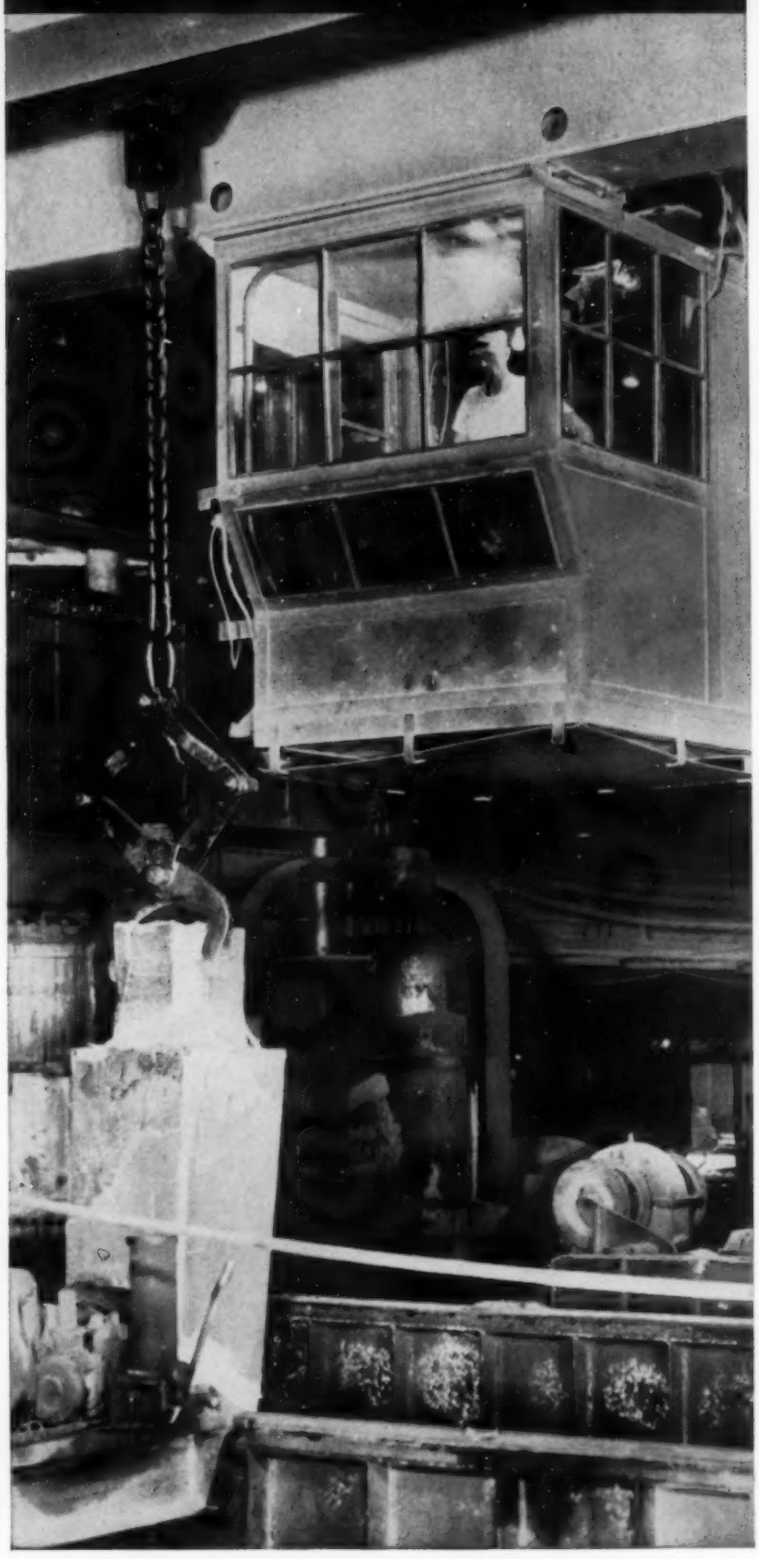
Loring S. Brock has been appointed director, product development division—commercial department of United States Steel Corp. In his new position Mr. Brock will be responsible for the commercial phases of product planning and the development of new products. These activities had been temporarily under the direction of **Robert C. Myers,** director of market development, who will now be able to devote full time to his principal responsibility as head of the market development division.

James E. Cochran has been appointed general plant foreman of Jones & Laughlin Steel Corp.'s Electricweld Tube Division, Oil City, Pa. Mr. Cochran, who was supervisor of methods and standards in the Industrial Engineering Department of J&L's Pittsburgh Works, replaces **W. R. Roesch,** who has been appointed assistant superintendent of maintenance at J&L's Cleveland Works.

Howard E. Miller has been appointed assistant chief metallurgist of the Cleveland, Ohio, steel plant of Republic Steel Corp. In his new job, Mr. Miller will be in charge of metallurgical operations at Republic's 98-in. strip mill. He joined Republic in 1938 as a tester in the hot strip mill. In 1942, he was named general metallurgical foreman of the cold strip mill and three years later, general metallurgical foreman of the hot strip mill. In 1946 he was appointed strip mill metallurgist and in 1953 became a contact metallurgist.

P. H. Reynolds, formerly assistant resident engineer of Jones & Laughlin Steel Corp.'s Pittsburgh Works, has been appointed staff engineer—rolling mills. Mr. Reynolds joined J&L in June, 1928, in the Aliquippa Works' Seamless Tube Department. He was named assistant resident engineer at Pittsburgh in January, 1951.

Steel mill solves problem of "the 30-minute crane operator"



. . . with DRAVO CRANE CAB CONDITIONERS

In this large Midwestern steel tube mill, heat above the 2300-degree soaking pits was so intense that crane operators had to be relieved every 30 minutes! This "heat-fume" problem was so critical that sometimes an operator collapsed from heat exhaustion and had to be removed for first aid. This was doubly hazardous since the men performing the rescue might also be overcome. Another problem was extremely dense and irritating dust and fumes plus heat encountered by the operator of the charging crane for the new electric furnaces.

Solution to these problems was the installation of Dravo Crane Cab Conditioners on the five cranes serving these "hot spots." Now, every crane operator has ample protection against fatigue and heat prostration. Every operator, alert and efficient in a *78-degree* cab, now works a complete shift without relief.

Because of Dravo Crane Cab Conditioners, the mill not only provided health and safety protection, but *also cut crane operating labor costs in half and increased production efficiency!*

No matter where they're put to work, Dravo Industrial Air Conditioners pay big dividends by providing effective protection from excessive heat, dust, dirt and fumes. We'd like to tell you more about how these efficient, rugged, easy-to-install units can help you. Why not mail the coupon now or phone the nearest Dravo sales office!

DRAVO
CORPORATION
PITTSBURGH, PENNA.
Sales Representatives In Principal Cities

Dravo Corporation, Air Conditioning Department
Fifth and Liberty Avenues, Pittsburgh 22, Penna.

- ☐ Please send Bulletin 1301 "Crane Cab Conditioners."
- ☐ Please send Bulletin 1304 "Cool Off the Hot Spots."
- ☐ Please have a representative call at no obligation to me.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

M. F. Glascock has been advanced from general superintendent of the Fairfield Sheet Mill, Tennessee Coal & Iron Division of U. S. Steel Corp., to general superintendent of the Fairfield Tin Mill, succeeding **John R. Hunt,** who becomes chairman—operating committees.

James M. Lewis formerly sales manager of Blaw-Knox Co., Rolls Division, retired August 1. He will, however, be retained as a consultant until January 30, 1956. Mr. Lewis will become a manufacturers' representative of the Pittsburgh district for Standard Diamond Tool Co., and Victor Tool Co.

Fred C. Frame has been appointed sales engineer of Salem-Brosius, Inc. Mr. Frame was vice president of

FRED C. FRAME

Kidd Drawn Steel Co., Aliquippa, Pa., from 1951 until he joined Salem-Brosius, and for 15 years prior to 1951 he had been staff assistant to the vice president of sales of United States Steel Corp.

David L. Doty has been appointed assistant to the director—technical services for Jones & Laughlin Steel Corp. He returns to technological work after five years as a salesman in J&L's Tin Mill Products Division. Prior to that time, he was metallurgical supervisor—wire and tin mill products, in the Aliquippa Works Division. He joined J&L in June, 1939, as a metallurgical investigator in Aliquippa.

John A. Gilroy was named plant engineer of Harnischfeger Corp., located at the company's main plants in Milwaukee, Wisc. Prior to joining P&H, Mr. Gilroy was for 13 years chief engineer for the Wyman-Gordon Co., at Harvey, Ill.

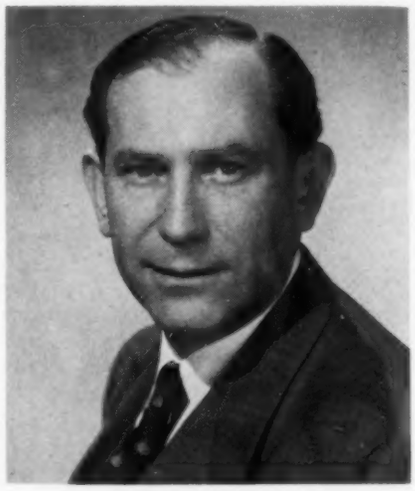
Leslie C. Bradburn has joined Rees Machinery Co., Inc., as a sales engineer. He was associated with the Linde Air Products Co. in Pittsburgh for the past 13 years as a welding engineer.

James W. Foley was elected executive vice president of the Texas Co. Mr. Foley was elected a vice president in 1953, and a director in 1954.

Clayton G. Findlay was appointed district manager in St. Louis, Mo. for the Electric Controller and Manufacturing Co.

Merle A. Miller was elected vice president and treasurer of Joseph T. Ryerson & Son, Inc., and **Raymond N. Carlen** was named vice president. Mr. Miller was formerly treasurer and assistant secretary, and Mr. Carlen was assistant vice president.

Alfred Fleissig was named general sales manager of Hydropress, Inc. Mr. Fleissig has been connected with



ALFRED FLEISSIG

the company since its inception, having worked originally in sales and, for the past fifteen years, in charge of purchases and contracting. He will retain his position as director of purchasing.

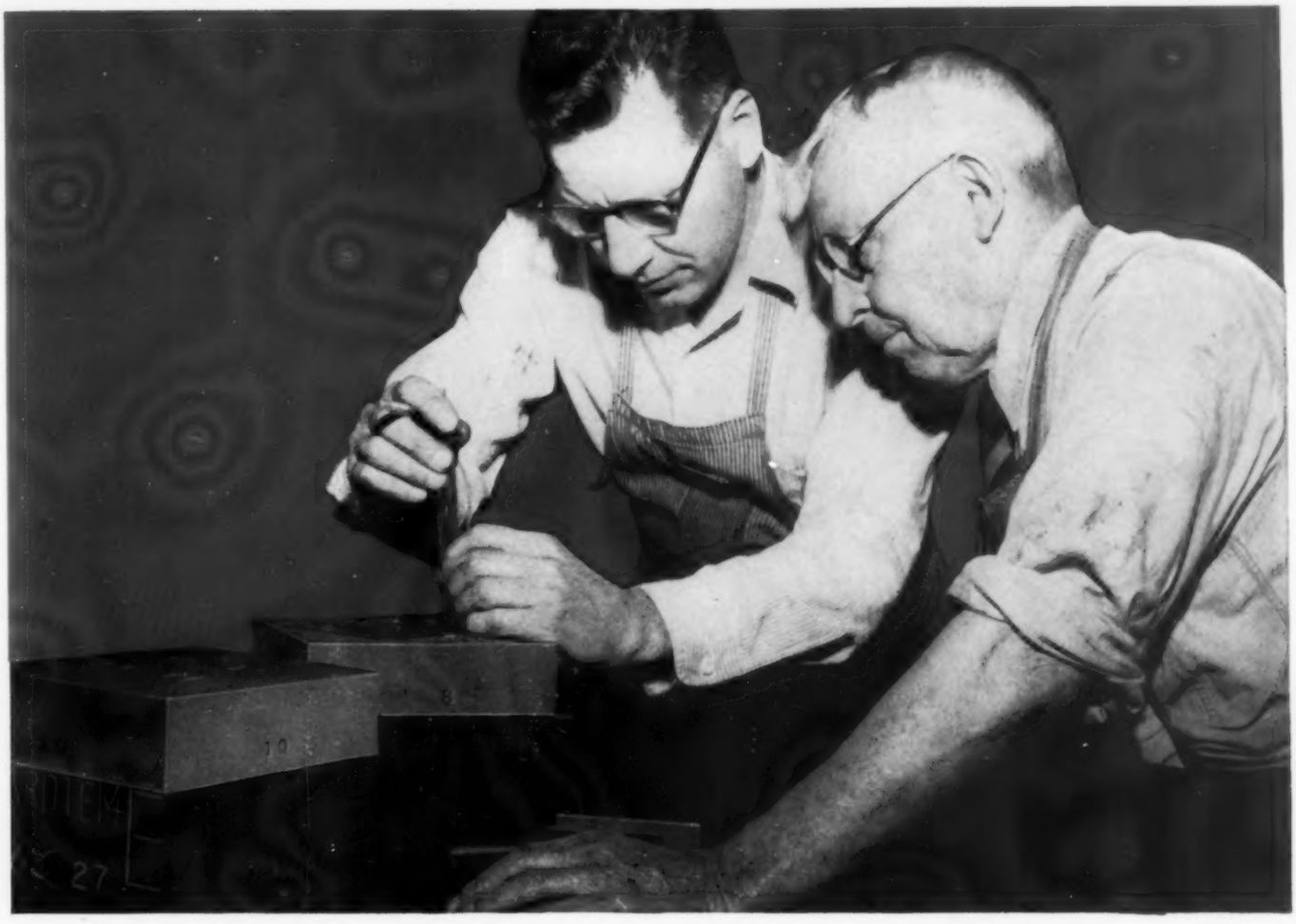
Walter A. Reynolds has been appointed district manager of the Garlock Packing Co.'s Denver, Colo. office, succeeding **M. J. Lester,** retired.

Frank P. Shonkwiler has been named manager of basic sales by Harbison-Walker Refractories Co. He

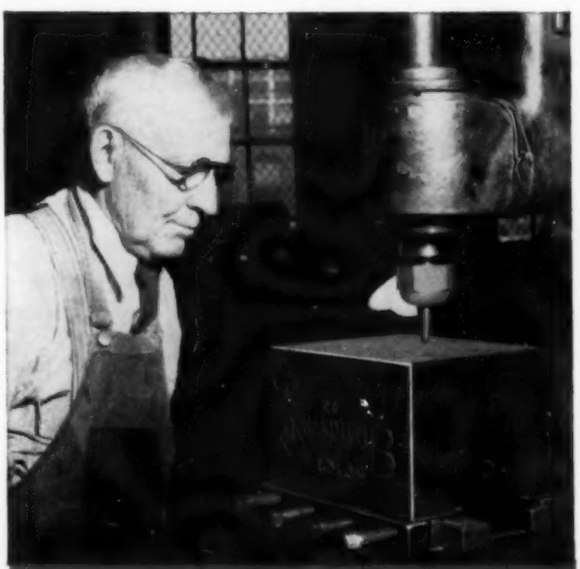
FRANK P. SHONKWILER

formerly was a member of the Chicago district sales staff. His headquarters now will be in Pittsburgh.

Harry L. Anderson has been appointed superintendent of the masonry department of Republic Steel Corp.'s Youngstown district steel plant. Mr. Anderson, formerly assistant superintendent of the mason and labor department of Republic's Warren district steel plants, joined Republic in the Cleveland general office



precision demands the best material



Among industry's top die sinkers, Hardtem Die Blocks have earned a time-honored reputation for dependability. Above is Mr. Justus Johnson, owner and operator of his own shop in Hartford, Conn. (He is shown with his son in the feature illustration.) Mr. Johnson, though 85 years old, still continues his daily work—applying his wealth of experience and knowledge to the trade he has worked in for so many years.

That's why users buy and rely on Heppenstall Hardtem Die Blocks—for the consistent performance they can trust.

Here's what Hardtem Die Blocks mean to Better Production!

1. They're tough . . . they resist impact stress.
2. They withstand heat.
3. They are uniform in hardness.

Here's why Hardtem Die Blocks assure better results!

1. They're built of a special patented Heppenstall Steel.
2. They're carefully forged and heat treated to provide the wear resistance for which they are recognized throughout industry.
3. Their quality is under constant study and development by Heppenstall's Engineering and Research staff.

Make Hardtem your standard die block specification. Heppenstall Company, Pittsburgh 1, Pa. Sales Offices in principal cities.

HEPPENSTALL

. . . the most dependable name in die blocks

MILLIONS OF FEET NOW IN SERVICE

BECAUSE OF PROVED PERFORMANCE

ROCKBESTOS

PNR SMALL DIAMETER CONTROL CABLE

There are still a few who haven't yet taken advantage of PNR . . . the lighter, smaller control cable. But it's come a long way since we first introduced its Polyethylene, Nylon, Rockhide insulation to industry just six short years ago.

Today, many utilities specify it. And there are millions of feet in service.

If you haven't tried it yet, get the complete PNR story today. Write or ask your nearest Rockbestos representative.

*Average determined by comparison with conventional control cable.

PROPERTIES OF PNR

46% smaller in area* . . . 28% smaller in diameter* than conventional control cable. Use smaller conduit and fittings or put more conductors in existing conduit.

Lighter, easier to handle, store, ship, pull through conduit.

Dielectric breakdown . . . over 40 times operating voltage.

Rated 600 volts . . . conductor operating temperature 167°F.

Flexible from 167° to —67°F. No cracking!

ROCKBESTOS PRODUCTS CORPORATION
NEW HAVEN 4, CONN.

NEW YORK • CLEVELAND • DETROIT
CHICAGO • PITTSBURGH • ST. LOUIS
LOS ANGELES • NEW ORLEANS
OAKLAND, CALIFORNIA

in 1948, moving to Warren in 1951. **Charles C. McGarry** succeeds Mr. Anderson as assistant superintendent of the mason and labor department at Warren.

Ralph E. Forsman has been named to the sales staff of Basic Refractories, Inc. Mr. Forsman will be located in the Philadelphia office. Prior to joining Basic he was associated with Youngstown Sheet & Tube Co. in East Chicago, Ind., Pittsburgh Crucible Steel Co. in Midland, Pa., and Sharon Steel Co. in Lowellville, Ohio. During much of this period Mr. Forsman worked as a melter on both open hearth and electric steelmaking furnaces.

Howard B. Cummings has been elected vice president in charge of manufacturing, Shenango China, Inc. Mr. Cummings was formerly director of manufacturing for the United Engineering and Foundry Co. Prior to that he was superintendent of United's plant at New Castle, Pa.

Obituaries

John Kloos, associated with the Morgan Engineering Co. for 65 years before his retirement last July 1, died July 15. Prior to his retirement, he had been field

JOHN KLOOS

service manager for the last 42 years. Mr. Kloos joined Morgan as an engineering machinist in August, 1889. Later, he served as an assembler, then field erector.

C. Howard Paul, former vice president, secretary, and treasurer of Mackintosh-Hemphill Co., died July 3. He was 61. When Mackintosh-Hemphill became a division of the E. W. Bliss Co. of Canton, Ohio on May 1, Mr. Paul was appointed assistant treasurer for the entire Bliss organization. He held this position at the time of his death. Mr. Paul joined Mackintosh-Hemphill in 1917. He became chief clerk in 1920, comptroller in 1924, assistant treasurer in 1928, assistant secretary in 1929, treasurer and assistant to the president in 1936, director in 1944, and vice president in 1952.

John C. Snyder, retired field engineer of the Electric Controller & Mfg. Co., died July 15. He was 68. Mr. Snyder joined EC&M in 1918, and served from the company's Pittsburgh office until his retirement in October, 1951.

GRID
UNIT HEATERS
Trouble-free heating service in the...
Major Steel Mills since 1929

...NO Maintenance or Repairs

The reason for this wide acceptance . . .
GRID'S All-Cast construction having similar metals in contact with steam prevents electrolytic corrosion.
GRID'S ability to withstand steam pressures up to 250# P.S.I.

GRID'S low outlet temperatures, proper fan sizes and motor speeds assure delivery of warm comfortable air in ample volume, directly to the spot where it is needed. Maintenance cost conscious management men turn to GRID for relief from the continuous expense of heating failures experienced with ordinary unit heaters. GRID Unit Heaters installed in 1929 are still operating today . . . the only attention needed has been an occasional oiling of the motor. No ordinary unit heater can approach this record.

- JONES and LAUGHLIN STEEL CORP.
- UNITED STATES STEEL
- CARNEGIE ILLINOIS STEEL CO.
- BETHLEHEM STEEL CORPORATION
- AMERICAN CHAIN & CABLE
- INLAND STEEL
- AMERICAN STEEL & WIRE CO.
- ARMCO STEEL CORPORATION
- WHEELING STEEL CORPORATION
- AMERICAN BRASS COMPANY
- YOUNGSTOWN SHEET & TUBE CO.
- ALLEGHENY LUDLUM

Get the full story today. Ask for booklet CORROSION IN UNIT HEATERS . . . it's yours upon request.

D. J. MURRAY MANUFACTURING CO.
Manufacturers Since 1883 • WAUSAU, WISCONSIN
REPRESENTATIVES IN ALL PRINCIPAL CITIES

GET EXTRA SUB-HEARTH

SAFETY AND LONGER LIFE

WITH KAISER PERICLASE D-S BRICK →

THIS superior brick has been *especially designed* to withstand sub-hearth conditions. Thus, it gives maximum protection against costly breakthroughs and provides longer sub-hearth life.

Steel men agree on the important properties for a sub-hearth brick. They are all found in Kaiser Periclase D-S Brick.

High MgO (more than 95%) is achieved through the use of pre-shrunk, accurately sized Periclase grains derived from sea-water magnesia. Absence of chrome eliminates the reduction of chromium oxide and damage to the refractory structure.

Low iron content minimizes refractory damage from alternate oxidation and reduction of iron oxide and other iron compounds. Absence of calcium oxide prevents damage caused by slaking during slow heat-ups or while furnace is idle.

With all its many advantages, Kaiser Periclase D-S Brick gives you the ultimate in sub-hearth safety and durability—*yet costs no more!*

Call or write Kaiser Chemicals Division, *Kaiser Aluminum & Chemical Sales, Inc. Regional Sales Offices: 1924 Broadway,* OAKLAND *12, California . . . First National Tower,* AKRON *8, Ohio . . . 518 Calumet Bldg., 5231 Hohman Avenue, Hammond, Indiana* (CHICAGO).

For the ultimate in steel furnace refractories . . .

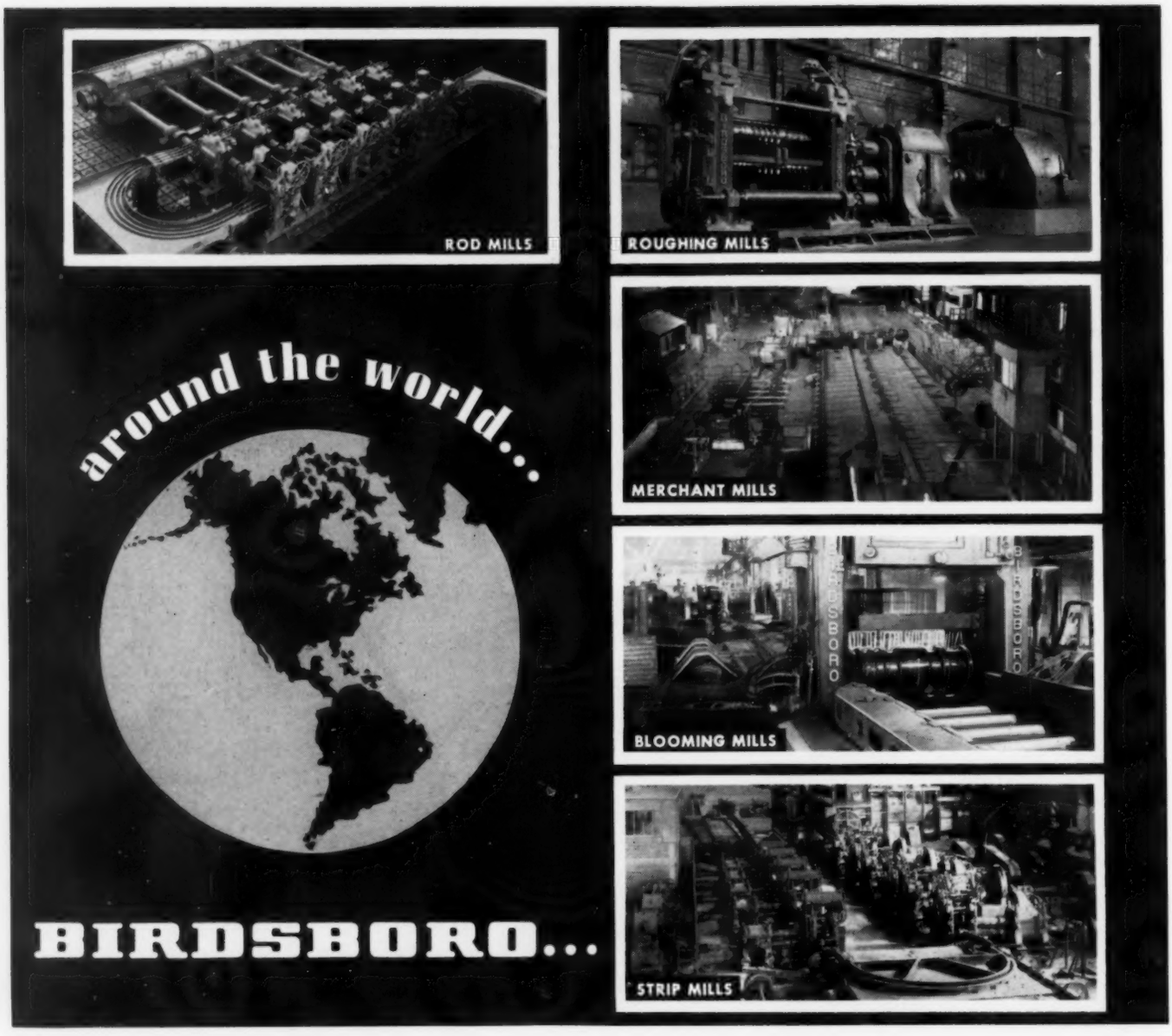
Kaiser PERICLASE Brick for the Steel Industry:
• Kaiser Periclase D-S Brick • Kaiser Periclase Chrome Brick • Kaiser Chrome Periclase Brick
Now available! A companion mortar for Kaiser D-S Brick. High purity periclase composition and maximum workability.
INSTALLATION ADVICE ON REQUEST

think of Kaiser Chemicals

Pioneers in Modern Basic Refractories

CHEMICALS KAISER REFRACTORIES

Refractory Brick, Ramming Materials, Castables & Mortars • Magnesite • Periclase • Deadburned Dolomite



is known for dependable mill equipment!

Designers and Builders of:

STEEL MILL MACHINERY
HYDRAULIC PRESSES
CRUSHING MACHINERY
SPECIAL MACHINERY
STEEL CASTINGS
Weldments "CAST-WELD" Design
ROLLS: Steel, Alloy Iron, Alloy Steel

• Whatever you need in mill equipment . . . wherever you need it . . . BIRDSBORO is ready to give you "customized" service, from the manufacture of a single unit to the design, building and installation of complete mills and auxiliary equipment.

MM 43-55

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., BIRDSBORO, PENNA. Offices in Birdsboro, Pa. and Pittsburgh, Pa.

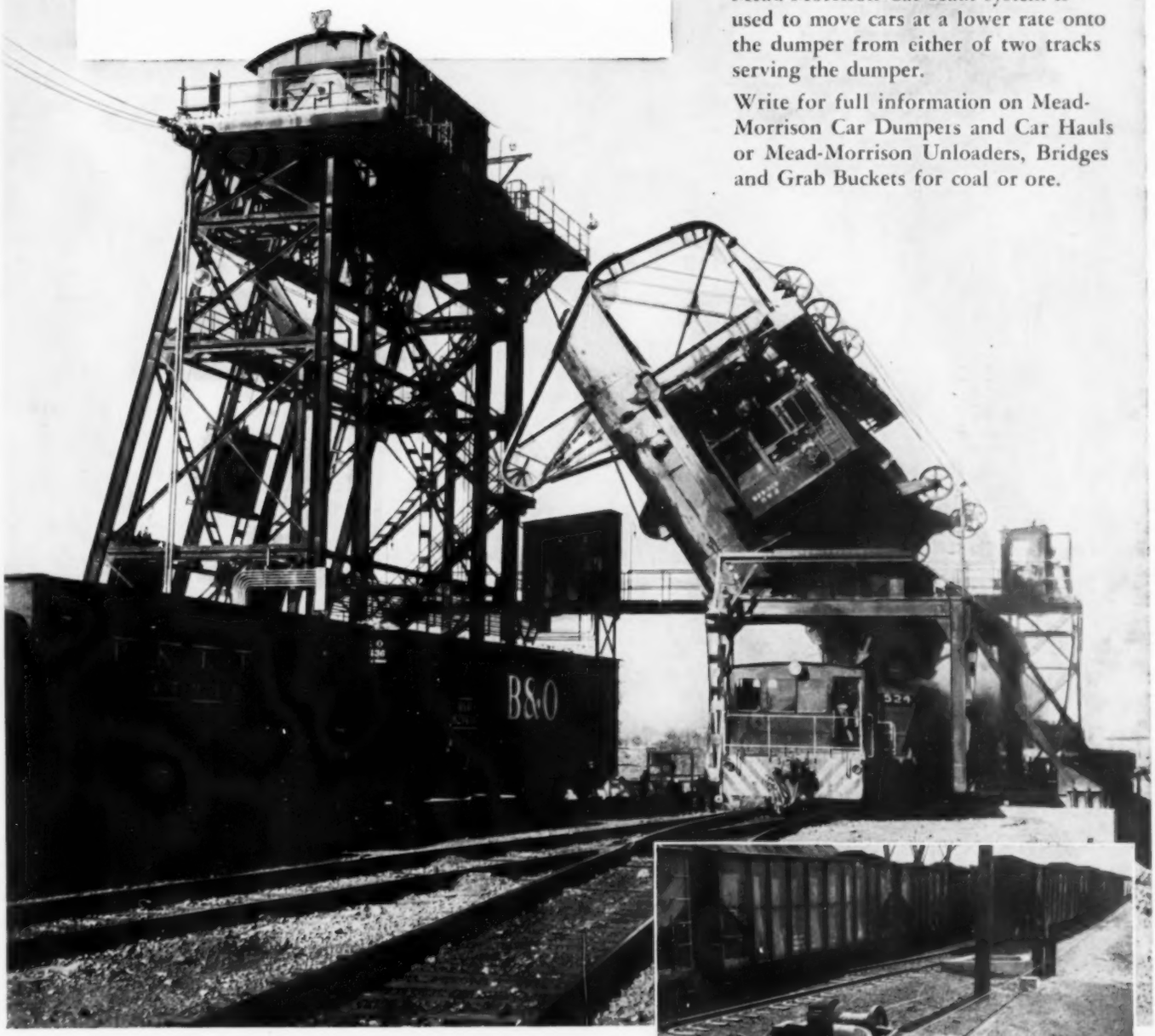
3,000 TONS
OF ORE PER HOUR
with this
MEAD-MORRISON
CAR DUMPER

Recently installed at a large midwestern steel company, this powerful, speedy Mead-Morrison Dumper can handle ore cars of 50-ton or 70-ton capacity at a maximum rate of 45 per hour.

The cars are received on the cradle of the dumper, and are turned over to discharge the ore through an open hopper into a transfer car on an adjacent track at the same elevation as the car dumper track.

When a locomotive is not available, a Mead-Morrison Car Haul system is used to move cars at a lower rate onto the dumper from either of two tracks serving the dumper.

Write for full information on Mead-Morrison Car Dumpers and Car Hauls or Mead-Morrison Unloaders, Bridges and Grab Buckets for coal or ore.



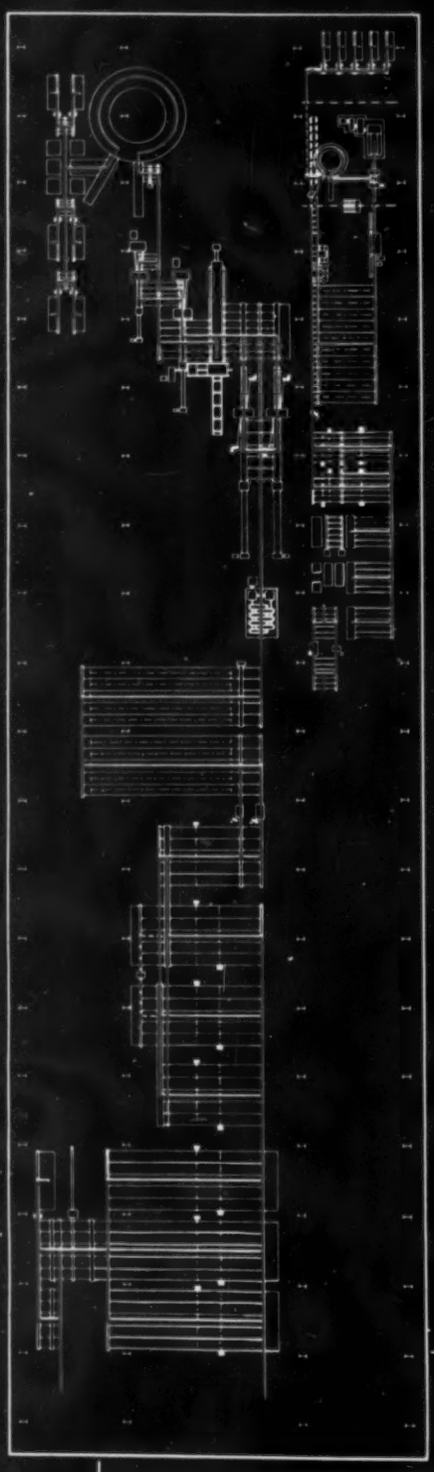
MEAD-MORRISON

Division of

McKIERNAN-TERRY CORPORATION

HARRISON, NEW JERSEY

MKBIB



Is there a standard way to build a tube mill?

Not according to what we've learned in many years of building and equipping tube and pipe mills.

Mannesmann-Meer's NO to this question is dictated by two factors – the individual needs of our various customers and the steady progress we build into our equipment.

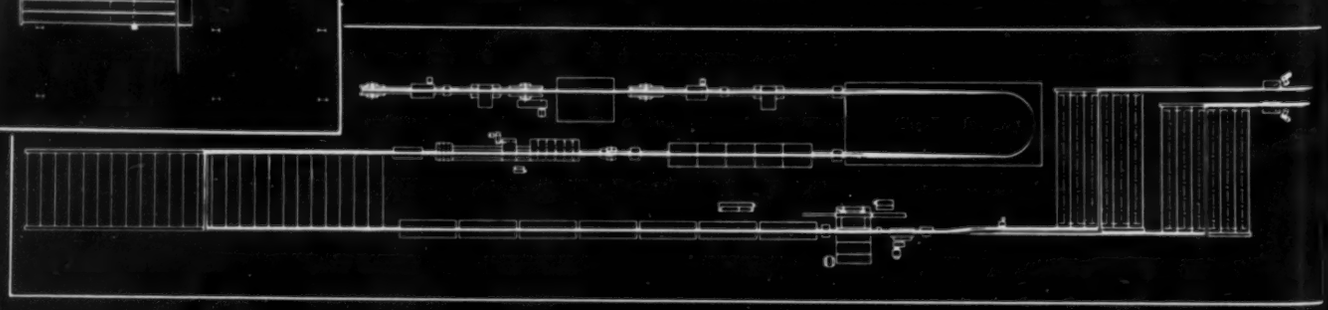
Here is an example. Economic needs and often other considerations lead many Companies into installing a new mill step-by-step. This procedure sometimes has marked advantages which show up in the mill layout and in the integrated planning for future steps of expansion, all of which will then be up-to-date. On the other hand mills for certain tubular products which must be installed all at once present different problems in plant engineering – with different solutions.

Meeting your individual needs and requirements is second nature for us. Nowhere else in the world is Mannesmann-Meer's combination of

- CREATIVE ENGINEERING
- DESIGN EXPERIENCE
- OPERATING BACKGROUND
- AMERICAN MANUFACTURING SKILL

available and ready to go to work on your tube and pipe mill problems.

Mannesmann-Meer Engineering and Construction Company, Inc.,
900 Line Street, Easton, Pennsylvania



MANNESMANN-MEER

World Specialists in High-Speed Tube Mill Machinery

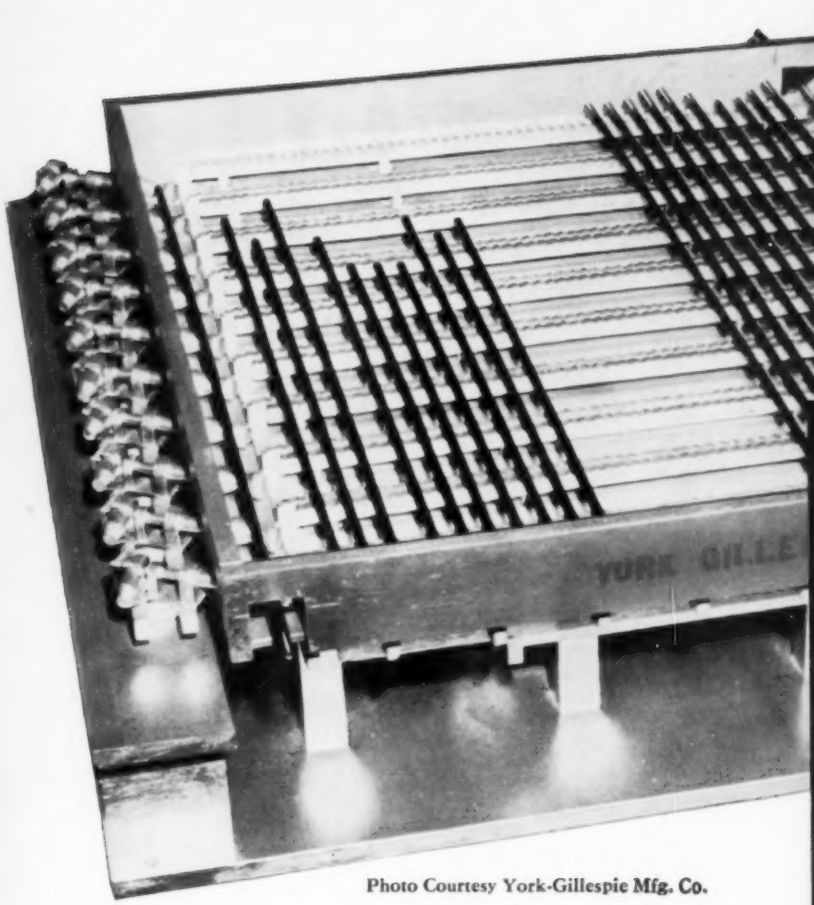


Photo Courtesy York-Gillespie Mfg. Co.

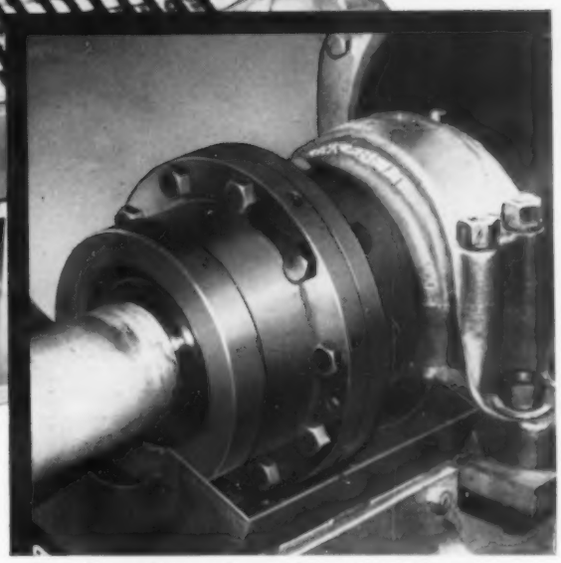


Photo Courtesy Jones & Laughlin Steel Corp.

Fast's Couplings help roll 30 tons of steel per hour through new Jones & Laughlin normalizing and quench tempering furnaces

At the Jones & Laughlin Aliquippa Works, Fast's Couplings are part of a new materials-handling process for transferring tubular steel products through the continuous normalizing and quench tempering furnaces. Pipe tubing is rotated automatically by a series of specially designed racks as it is transferred through the furnace. This design eliminates chill spots and minimizes warpage, insuring uniform heating at capacities up to 60,000 pounds per hour.

Fast's Couplings were used exclusively in this equipment . . . and for good reasons: They are subject to operation at extremely high temperatures that demand Fast's all-steel construction; torque transmission is high (low 3 RPM speed at eccentrics); Fast's Couplings offer mis-alignment protection for long-distance shafting—particularly important because of high temperatures and subsequent shaft growth; and Fast's Couplings are the best "shut down insurance" where continuous, trouble-free operation is essential.

This is another example of how Fast's Couplings fill specialized needs of industry with their famous Fast's construction and performance features. Koppers free engineering can assist you in selecting the right Fast's Coupling for your needs also. Mail the coupon below for a free catalog to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 218 Scott St., Baltimore 3, Maryland.

THE ORIGINAL *FAST'S Couplings*

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus. ***Engineered* Products Sold with *Service***

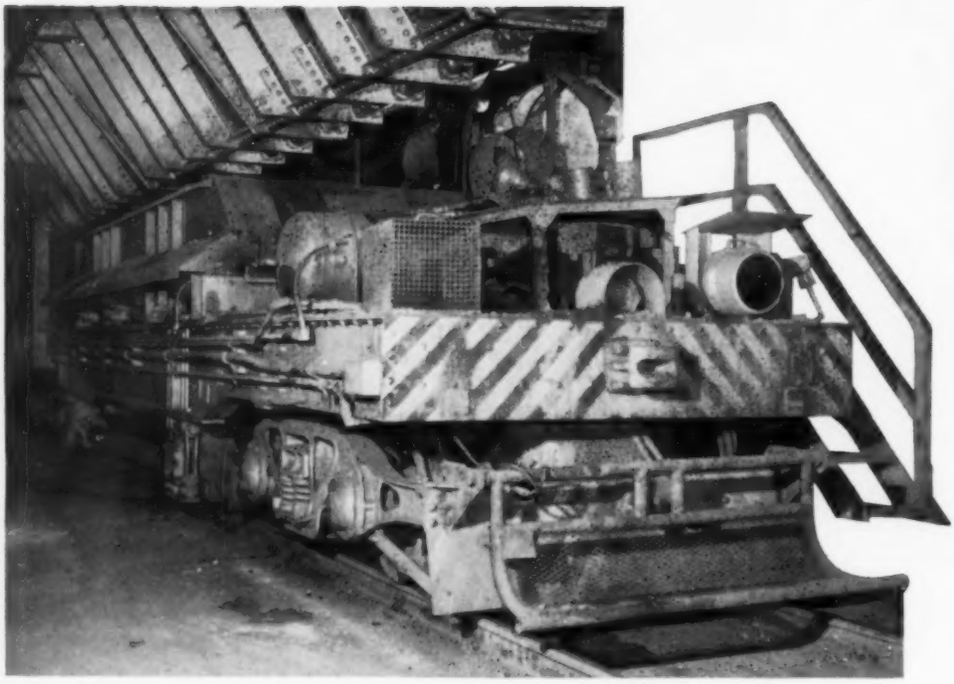
KOPPERS COMPANY, INC., *Fast's Coupling Dept.*, 218 Scott St., Baltimore 3, Md.
Gentlemen: Send me a Fast's Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

Company.....

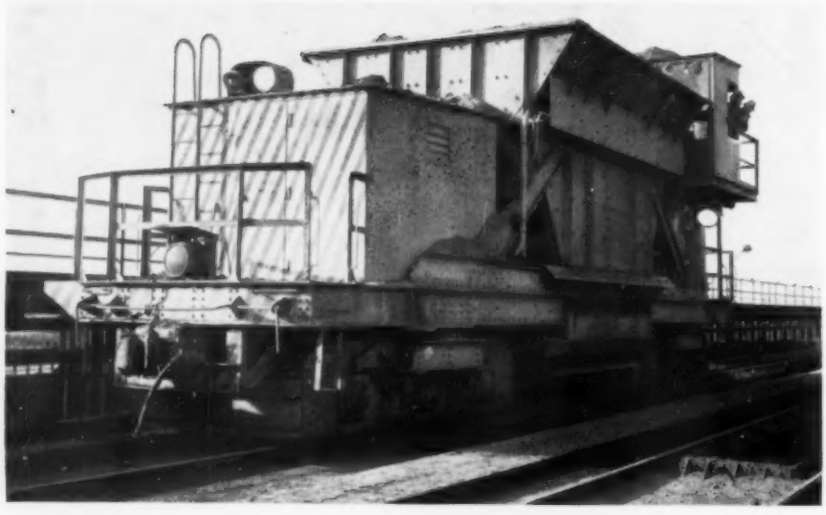
Address.....

City.....Zone.....State.....



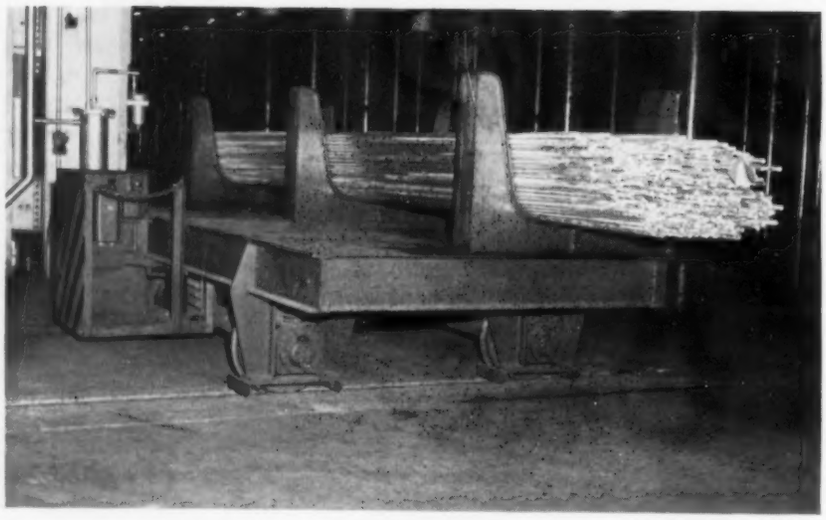
ATLAS CARS

known for their



DEPENDABILITY

These cars set the standards for operating economy, low maintenance, and safety. They are products of Atlas engineering skills acquired in over 50 years' service to America's blast furnace and steel plant operations.



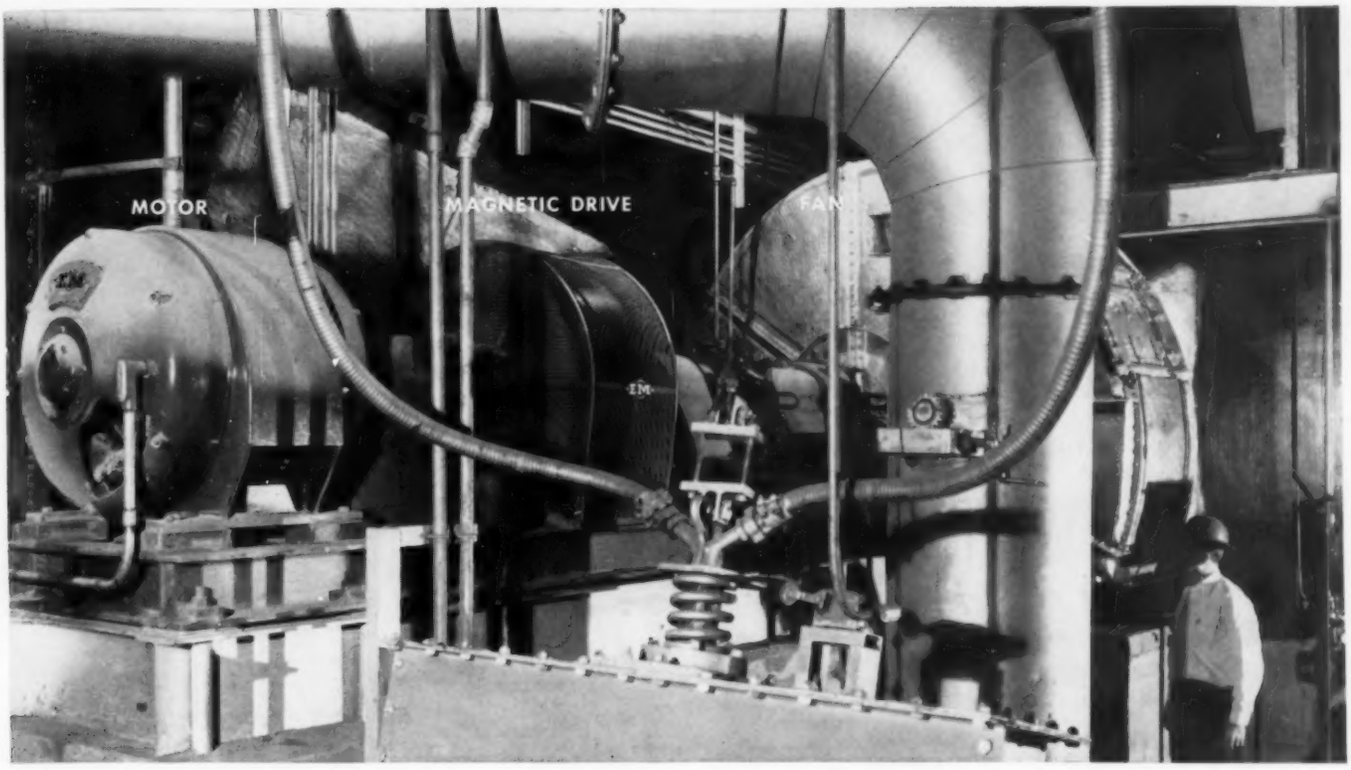
TOP — 40-Ton Scale Charging Car shown in stockhouse. Car is of bottom dump, double compartment construction.

CENTER — 120-Ton Side Dump Ore Transfer on highline.

BOTTOM — 32-Ton Flat Car with cradles for pipe handling. Power is supplied through cable reel. Two operator platforms for double-end control.

THE ATLAS CAR AND MANUFACTURING CO.

1140 IVANHOE ROAD **SINCE 1896** **CLEVELAND 10, OHIO**



A waste-heat boiler induced draft fan in a large steel mill receives driving power and precise speed control from a 200 hp, 720 rpm E-M Synchronous Motor and a 200 hp, 350/705 rpm EM Adjustable-Speed Magnetic Drive.

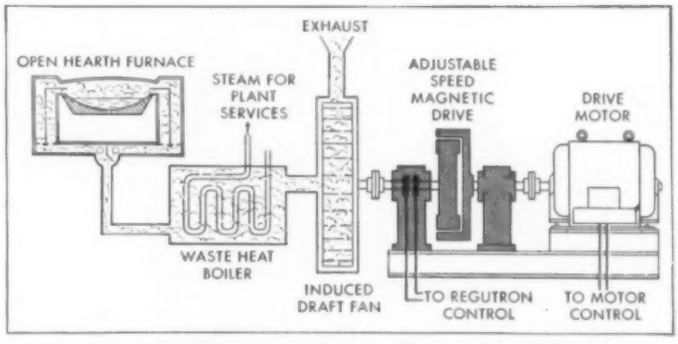
How to reduce erosion of waste-heat boiler induced draft fans

Many modern steel plants now use waste heat from banks of open hearth furnaces to produce steam for plant services. An induced draft fan draws waste gas through a waste-heat boiler to recover heat from open-hearth gases usually exhausted out a stack.

Speed control of this fan is essential for economical operation, and the E-M Adjustable-Speed Magnetic Drive is the best answer to this need. It transmits torque electromagnetically from the constant speed drive motor to the fan, responding automatically and precisely when speed changes are signalled. This Drive, with the sensitive E-M Regutron Control, provides *true* speed control regardless of variations in operating conditions.

Sizable reductions in fan blade erosion are achieved, as the fan is not required to run constantly at full speed against the highly abrasive gases when reduced output is wanted. The Magnetic Drive is equally effective and economical in drawing cool air through the boilers during shut-down for boiler maintenance or repair.

See how this Drive can save costs and increase over-all efficiency in your plant. Ask your nearest E-M sales engineer for details, and write for E-M Publication No. 1107 on Magnetic Drives.



Here, in a simplified diagram, is how the E-M Adjustable-Speed Magnetic Drive fits into the Waste-Heat Boiler system, providing precise, automatic control of the induced draft fan.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

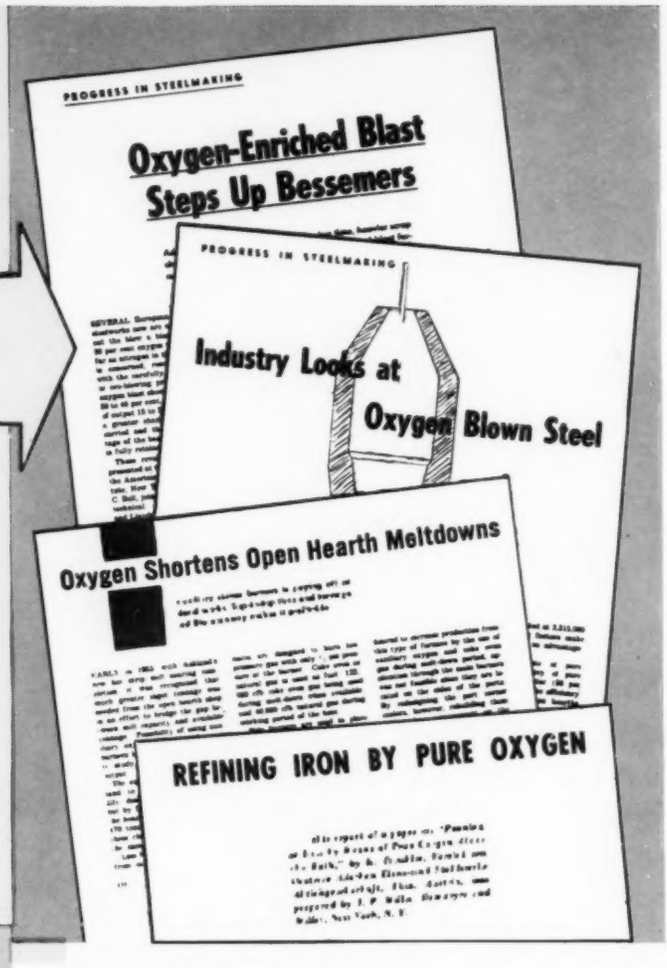
4400-TPA-2145

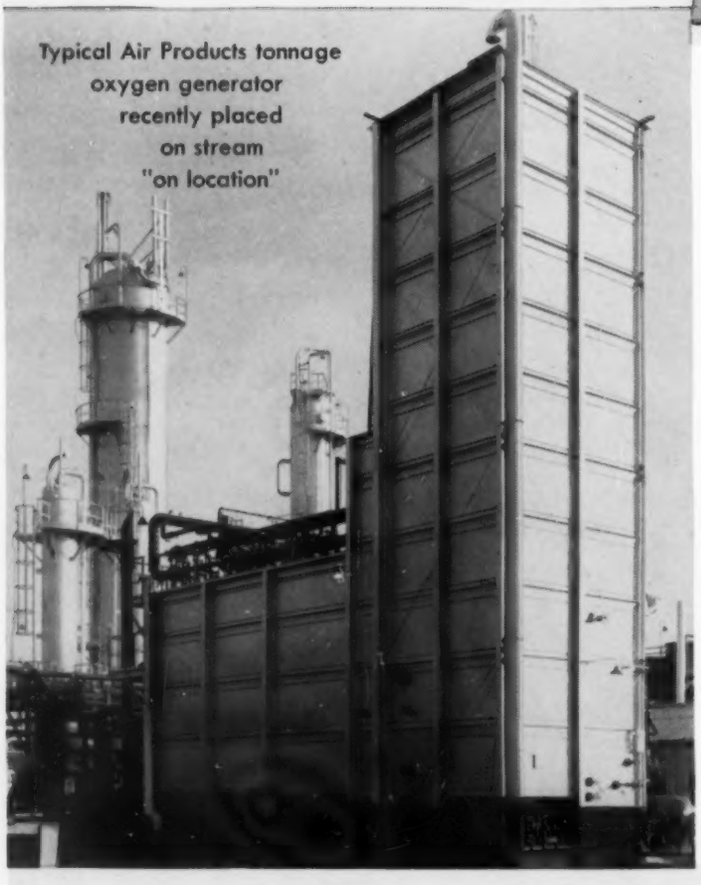
Magnetic Drives make draft fans do
EXACTLY WHAT YOU WANT THEM TO

LAST YEAR'S PREDICTIONS

. . .

—THIS YEAR'S REALITY


PROGRESS IN STEELMAKING
Oxygen-Enriched Blast Steps Up Bessemers
PROGRESS IN STEELMAKING
Industry Looks at Oxygen Blown Steel
Oxygen Shortens Open Hearth Meltdowns
REFINING IRON BY PURE OXYGEN



Typical Air Products tonnage oxygen generator recently placed on stream "on location"

A year ago we ran an advertisement entitled "Prepare for Progress in Oxygen Steel-Making". In it we predicted great increases in the use of oxygen for top-blast conversion, flame enrichment, desiliconizing, hot-top heating, etc.

Already the top blast conversion method of producing steel in the United States, using large quantities of oxygen generated "on location", has become a reality. This new method permits increased steel production with lowest possible increase in capital investment and operating expense. For these reasons progressive steel producers are planning similar installations.

If you are planning the large scale use of oxygen in your own steel-making methods, get in touch with us. We provide:

Large Capacity Tonnage Generators for unlimited quantities of oxygen and nitrogen, in standard or special models, high or low pressure cycles—

and

"Packaged" High-Purity Generators, producing high-purity oxygen and nitrogen simultaneously or individually.

We can install oxygen and nitrogen generators to suit your needs, on a lease basis, WITHOUT CAPITAL INVESTMENT BY YOU. Tell us your requirements and we will give you actual figures on the savings you can expect through the installation of a generator in your plant.

More than 100 Air Products engineers are at your service.

LOW COST OXYGEN...NITROGEN

Air Products
INCORPORATED

Dept. P Box 538, Allentown, Pa.

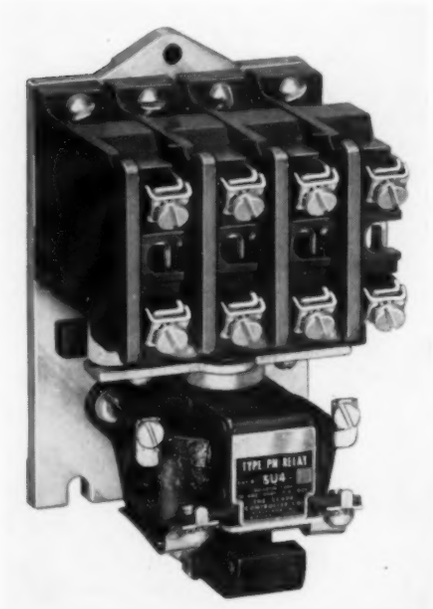
Equipment News...

CONTROL RELAYS

▲ Clark Controller Co. has announced a new line of 10-amp control relays designed to occupy minimum panel space without sacrifice of ruggedness, yet to provide an actual increase in ease of wiring and maintenance. The line includes relays with from two to twelve poles.

The relays feature a unique sectional pole design. Each pole is mounted in its own individual melamine block. Poles are individually removable and replaceable without disturbing other poles or other wiring.

Another feature is that relays with up to eight poles are available with-



out the complicated wiring and vertical space requirements of double-decking.

Construction of the pole blocks is such that each pair of contacts is contained in its own arcing chamber, with melamine walls between poles. This permits relays to be mounted side-by-side with practically no clearance required. On top, the poles are also enclosed, forming a continuous melamine shelf on which wiring may be run, thus saving from one to three in. in wiring trough width. On the bottom, only $\frac{7}{8}$ in. is required for changing the magnet coil.

Two basic sizes of the relay cover all ordinary relay needs from two to eight poles, and two magnet coils for a given voltage will cover almost any combination of normally-open and normally-closed contacts up to eight poles.

NAIL MACHINE

▲ Production of improved quality nails in greater quantity over a shorter period has resulted from the installation of new nail machines at Bethlehem Steel Co. plants in Johnstown, Pa., and Sparrows Point, Md. —13 machines at the former, 14 at the latter. These modern machines, with individual electric motor drive and tungsten carbide gripper dies, cutter dies, hammers, and feed grip inserts, turn out 700 nails per minute in any size within the machine range.

This is approximately five lb of 8d common nails per minute, or 25 one-hundred lb kegs or cartons every eight hours per machine. Amount and weight vary with the size of the nail being produced. The machines can be adjusted to handle nail wire sizes from 15 to $10\frac{1}{4}$ gage, inclusive, and to turn out nails from 1 to $2\frac{1}{2}$ in. long, inclusive.

Because of their precision adjustments and the use of the tungsten carbide tools, these machines turn out a superior product with sharper points and closer tolerances over a longer continuous operating period than was considered possible with any previous installation.

Nailmakers and reels are equipped with automatic safety devices to stop them should their operating functions be interfered with. Oil is supplied under pressure or by gravity to moving parts. A magnetic belt removes the nails to nail buggies.

The new nailmakers are part of an overall improvement project at the Bethlehem nail mills. Also included in the improvement program are paperboard container folding devices and stapling machines and a new packing line keeping pace with the faster production of the new equipment.

CABLE VULCANIZERS

▲ A new electrically operated cable vulcanizer, reported to weigh only 16

Delivery end of the high-speed nailmakers, recently installed at Bethlehem's plants in Johnstown, Pa., and Sparrows Point, Md. Finished nails are carried on a magnetic belt from the machine to nail buggy in the inclined enclosure at right.

HERC-ALLOY

SLING CHAINS

● Herc-Alloy is the only exact-size alloy chain on the market. This uniformity gives you a lighter and easier-to-handle chain without any sacrifice in working load limit.

● Herc-Alloy, the original alloy steel chain, is available in running lengths as well as in all types and sizes of slings made to customer specifications.

● Write for Bulletin 100 covering Herc-Alloy Sling Chains, including helpful information on their care, use and inspection.

● CM also produces a complete line of chain attachments and welded chain of all types including stainless steel and bronze.

CM HOISTS AND CHAIN

COLUMBUS McKINNON CHAIN CORP.
Tonawanda, New York
Regional Offices: NEW YORK • CHICAGO • CLEVELAND
In Canada: McKINNON COLUMBUS CHAIN LTD., ST. CATHARINES, ONT.
Herc-Alloy®

lb, less molds, yet capable of making repairs on cable up through two in. in diameter, has been developed by the Joy Manufacturing Co.

Available for use on standard a-c and d-c voltages with a wattage rating of 1000, these new units are designed to make quick "on the job" jacket repairs or to completely replace insulation and jacketing when splices are required.

Aluminum molds for use with these vulcanizers have been developed to cover most standard and many special types of cord and cable.

PRINTER

▲ Jas. H. Matthews & Co., has reported several important innovations in their hand operated bar and tube printer. The printer was originally developed for continuous printing along the length of any materials in the metal or plastic fields. It automatically adjusts itself to practically any size of round, square, flat or multi-sided surface.

A special material with high absorption qualities and ability to better distribute practically all colors of ink makes it possible to produce clear, unsmudged impressions.

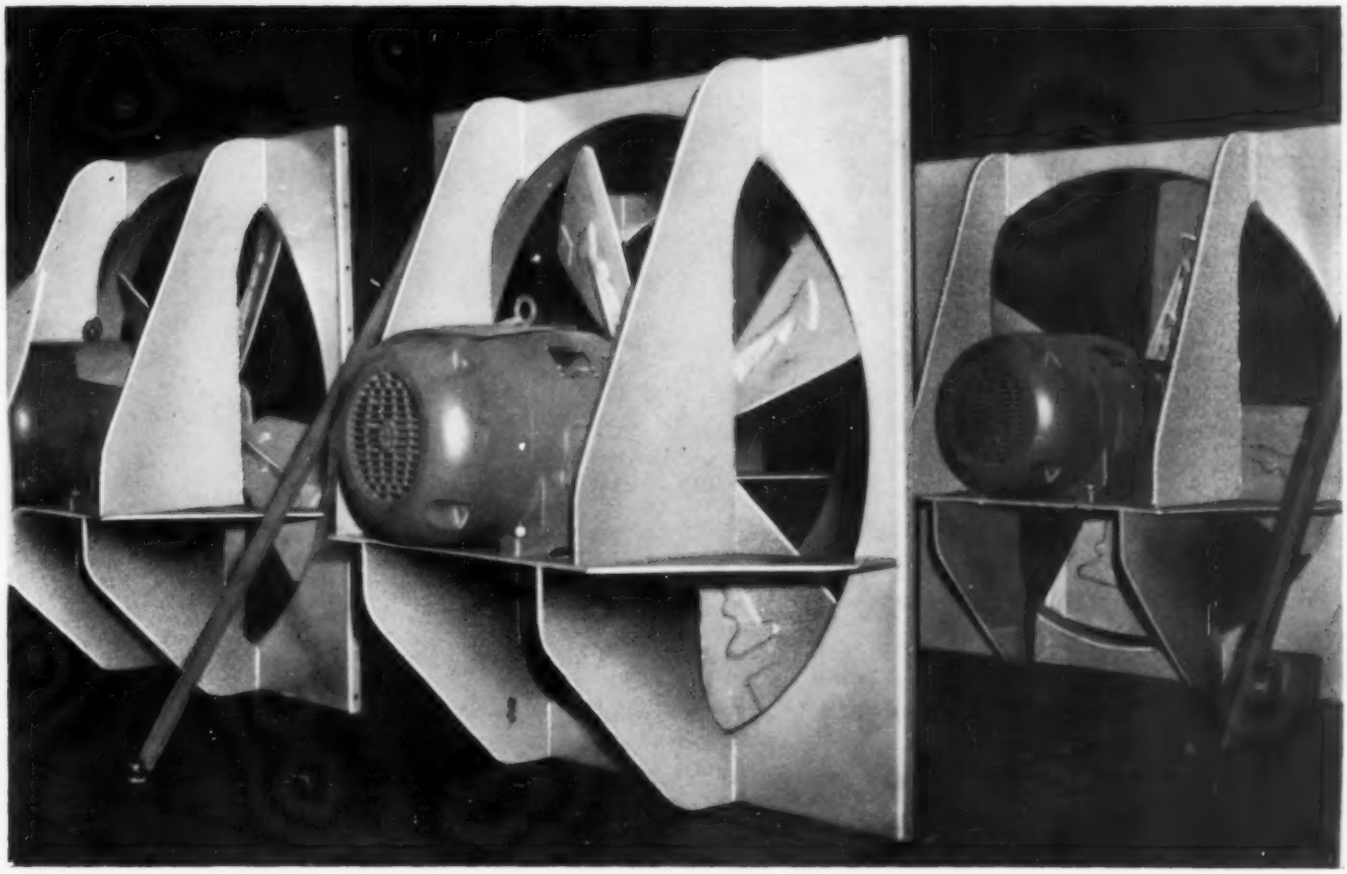
Contour molded rubber type can be quickly and easily set up in the printing wheel.

Sturdily built, though amazingly light, its 6½ lb is almost half the weight of previous models.

SHEET LIFTER

▲ F. J. Littell Machine Co. announces the new 8-cup vacuum roll-over sheet lifter. This lifter has a lifting capacity of approximately 14,000 lb. It can easily and safely handle sheets of any non-porous material up to five ft wide by 20 ft long weighing 2000 lb with a seven to one safety factor. The lifter is equipped with a U-hook for attaching to an overhead crane. Sheets may be moved to any location in the plant with complete safety. Lifting of the sheets is accomplished by vacuum produced by two pumps. The vacuum is conveyed by tubes through a storage tank to the eight rubber cups. No scratches can be made on the sheets as only rubber comes in contact with the surface.

There is no longer any need for pinch bars to separate sheets or for grappling hooks for lifting the load.



Part of eleven "Buffalo" 54" Package Fans now ventilating the mill motor room of a large eastern strip mill.

Steel Plant SOLVES TOUGH MILL MOTOR ROOM VENTILATION PROBLEM

with "Buffalo" PACKAGE PROPELLER FANS

These heavy duty ruggedly constructed units are gaining wide acceptance in steel mill installations. Here, eleven of the above "Buffalo" units pull outside air in thru two banks of cleanable and electrostatic filters, discharging into the mill motor room. They're built to take this tough air moving job, too! Note the sturdy ¼" steel plate square flanged panels and the ⅜" steel plate support gussets welded to the panels. The heavy die-stamped blades are welded to rugged cast steel spiders. Motors are 15 h.p., 860 R.P.M.

What hot spots in your plant would you like to ventilate at propeller fan cost? "Buffalo" offers you the complete selection — sizes up to 144" wheels — power roof ventilators — all kinds of special models to suit your application. Write today for Bulletin FM-1234 and see the astonishing variety of jobs these "Q" Factor* fans are doing well and inexpensively.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY
173 MORTIMER ST. BUFFALO, NEW YORK
PUBLISHERS OF "FAN ENGINEERING" HANDBOOK
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.
Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Sheet lifter separates and handles the sheets without damage.

The unique feature of the sheet lifter is its ability to rotate the sheet 180 degrees. Sheet or plate when inverted can be carried with complete safety and without dependence upon vacuum. Rotation may be stopped at any angle from horizontal to 180 degrees, making inspection of both sides of sheet simple and easy. It also provides an excellent means of vertical stacking of sheets. The operation of the lifter and the handling of the material can now be accomplished by only one man.

Larger sheet lifters can be supplied to lift sheets or plates weighing up to 4000 lb.

STRAIN INSULATOR

▲ Developed by Electric Service Manufacturing Co., is a new, high-strength, 750-volt capacity strain insulator, which because of its 2 in. diameter and $2\frac{13}{32}$ in. length is the smallest on the market.

The insulator has ultimate mechanical strengths, depending upon the assemblies, as high as 14,500 lb. Ultimate electrical puncture strength is in excess of 20 kv. Quality is insured by routine electrical tests at 7 kv.

The large diameter of this tapered insulator is 2 in. narrowing down to $1\frac{5}{8}$ in. This design provides extra clearance for collectors as well as permitting use of smaller angles and closer conductor spacings. The new insulator design provides a greater leakage distance, thus reducing chances of contamination.

In structure the insulator is molded of a high grade phenolic around a new high strength steel reinforcement assembly. Excessive vibration does not loosen the steel inserts from the phenolic. The assembly is so economical that it has already found wide usage as a replacement to troublesome wooden conductor supports.

DESCALING COMPOUND

▲ A mildly acidic compound for barrel deburring, descaling, and derusting, has recently been introduced by Oakite Products, Inc.

Known as Oakite FM184, the new material was specifically designed to replace raw acids in barrel operations, where alkaline materials and abrasives are impractical because of time limitations. It is also designed to improve color of steel after alkaline deburring; to remove heat scale from steel; and to brighten brass, either with or without the use of abrasive media.

The compound is said to have good foaming properties at the recommended concentrations of one to three oz to the gallon of water. It may be added dry to the burnishing barrel.

MAGNETIC PULLEY

▲ A magnetic pulley weighing more than 12 tons, and used to reclaim iron from slag has been manufactured by Stearns Magnetic, Inc.

The electro pulley is 60 in. in diam, and has a 60 in. magnetic face. The unit is supported by an eight in. diam shaft, and is installed as a head and drive pulley on a 60 in. wide conveyor.

GRAPHITE BRICK

▲ Announced by Mexico Refractories Co. is a new graphite brick which has given up to 31 days' service in a cupola well carrying 350 to 450 tons per day.

A year's tests have proved that the brick offers substantial savings in materials costs and maintenance. The company claims the cheapest pouring cost for a cupola well that can be obtained from any product on the market.

Evidence of longer service life is shown in numerous reports of results such as 11 to 14 days' service without patching from the brick in cupola wells; a well in operation 24 days, requiring very little patching to maintain good working condition; a 25 per cent materials saving, as well as a

(*Please turn to page 203*)

cut down shutdowns..

NON-SHRINK

EMBECO

PRE-MIXED

GROUT

Widely used in the iron and steel industry to produce non-shrink grouts for all types of heavy equipment and machinery, including rolling mills, drives, motors, hydraulic presses, planers, shapers, etc.

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Many advantages over plain cement-sand grouts—

- *Non-Shrink* with full bedplate contact... maintains alignment.
- *High Compressive and Impact-Resistant Strength*... takes vibration, pounding action.
- *Oil and Water Resistant.*
- *Flowable—Easily Placed* yet does not shrink upon hardening.

Recommended by leading equipment manufacturers.

EMBECO PRE-MIXED GROUT IS READY TO USE—you add only water. Write for 8 page illustrated booklet.

Creators and Manufacturers of Products to Improve Concrete and Mortar

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Special Purpose Lighting...

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EXPLOSION-PROOF FIXTURES
for N.E. Code Class I Locations

Operate at temperatures below ignition temperatures of surrounding explosive gas-air or vapor-air mixtures. Resist internal explosions without damage. Prevent escape of flames to surrounding atmospheres.

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CROUSE-HINDS Engineers will survey your layouts for lighting hazardous industrial locations . . . describe National Electrical Code safety regulations . . . suggest precautions to observe . . . recommend UL-approved fixtures for each danger-area, etc.

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Condulet
DUST-TIGHT FIXTURES
for Class II Locations

Exclude combustible dusts from interior of fixture. Even when fixture is completely blanketed with dust, temperature of fixture will not cause ignition.

Condulet
FLUORESCENT FIXTURES

Fluorescent fixtures also available for Class I, Group C and D; Class II, Groups E, F and G; and Class III.

Condulet
VAPORTIGHT FIXTURES
for Class III Locations

Protect bulb, receptacle and wiring from moisture and corrosive vapors in damp locations. Enclosures are designed to prevent entrance of fibers and flyings, escape of sparks, burning material or hot metal.

● ***Write, wire, or call your nearest Crouse-Hinds Office for complete details.***

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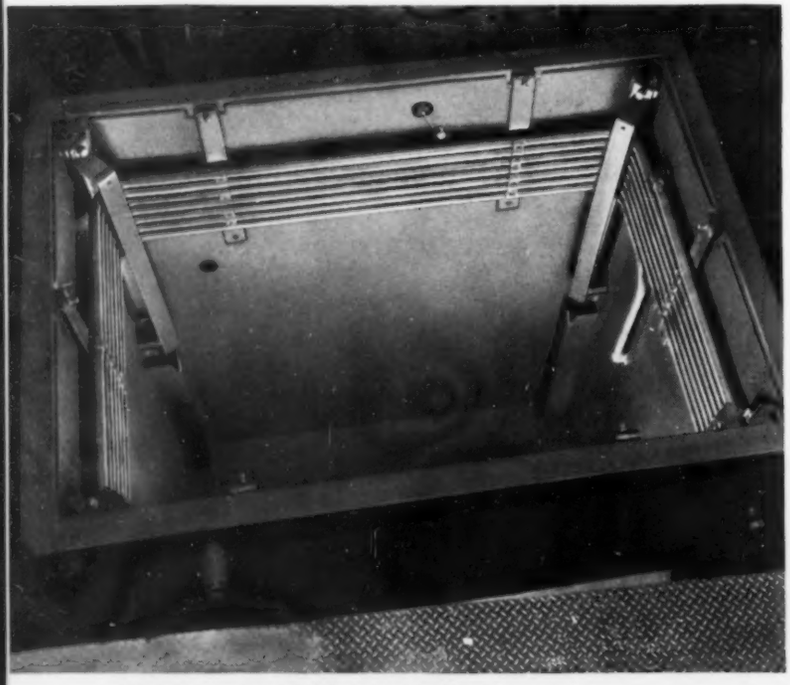
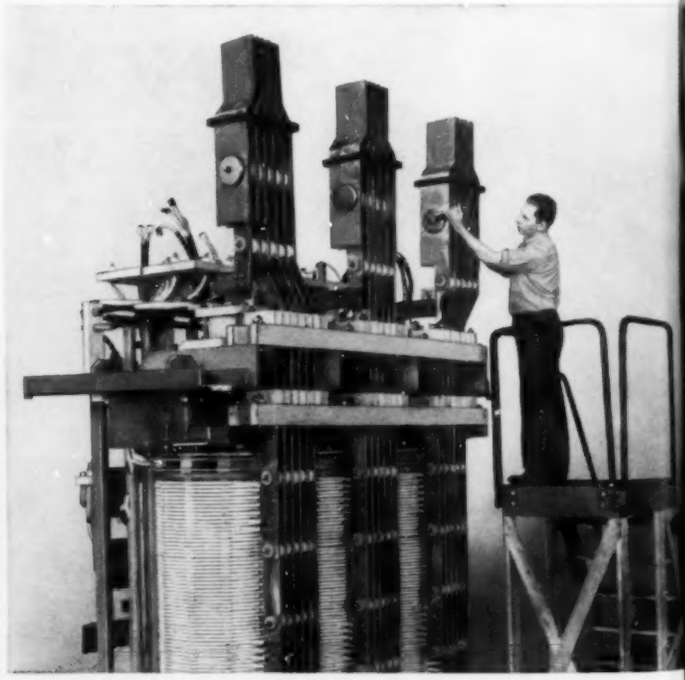
ELECTRIC ARC FURNACES teamed with dependable General Electric transformers provide the most rapid and economical method for the production of increasing quantities of all grades of steels.



INTERNAL WATER-COOLING COILS permit a more compact design using less floor space. Coils are located near the top oil level for maximum cooling effectiveness.



STURDY CORE AND CLAMPING STRUCTURE with circular concentric windings provides maximum strength to withstand repeated heavy current surges.

PAIR-UP your new arc furnace with a reliable G-E Transformer

Specially built for heavy-duty furnace work, with dependable control for all melting processes

You will get the best service from your new arc furnace if it is powered by a G-E arc furnace transformer. Built by General Electric for over 40 years, they are specially braced to absorb the jolting stresses caused by fluctuating heavy currents. High short-circuit strength is assured by the use of G-E pioneered circular concentric windings.

Liberal cooling ducts are provided within the core and the coil stacks. Ample water-cooling coils are mounted inside the transformer near the top oil level where they produce the most efficient cooling and occupy the least amount of space.

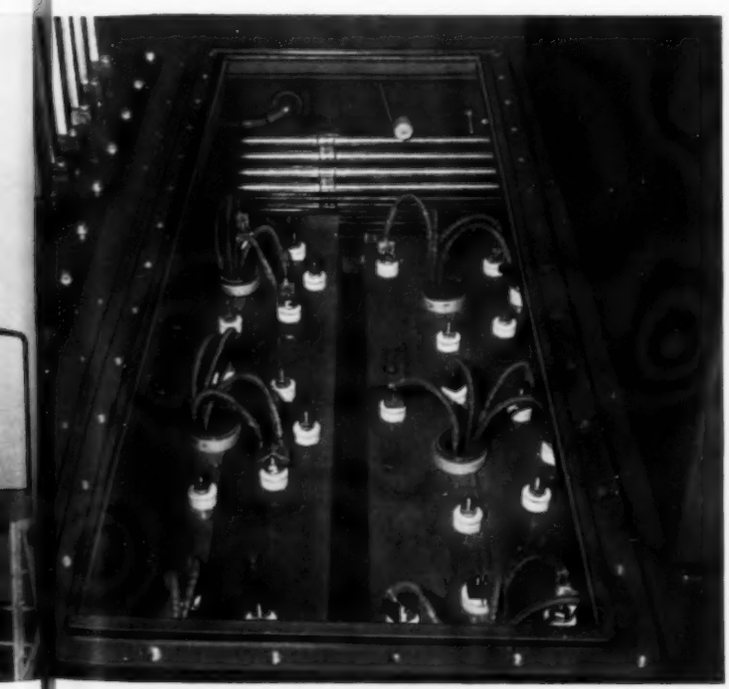
BETTER POWER CONTROL is maintained by the G-E wedge-type tap changing mechanism. It normally requires no maintenance and is both electrically and mechanically interlocked to help safeguard against tap changes when the transformer is energized. A wide selection of secondary voltages and reactance permits the most rapid and efficient operation for each type of melting procedure.

So, the next time you plan the purchase of an arc furnace, specify a General Electric transformer. In fact, for greatest economy and reliability ask for the entire G-E arc furnace electrical package, which includes the famous Magne-blast breaker, Amplidyne electrode control, and Tri-Clad* motors. If you would like to know more about G-E arc furnace transformers, ask your G-E Apparatus Sales Engineer, or write for bulletin GEA-6236 to Section 422-23, General Electric Company, Schenectady 5, N. Y.

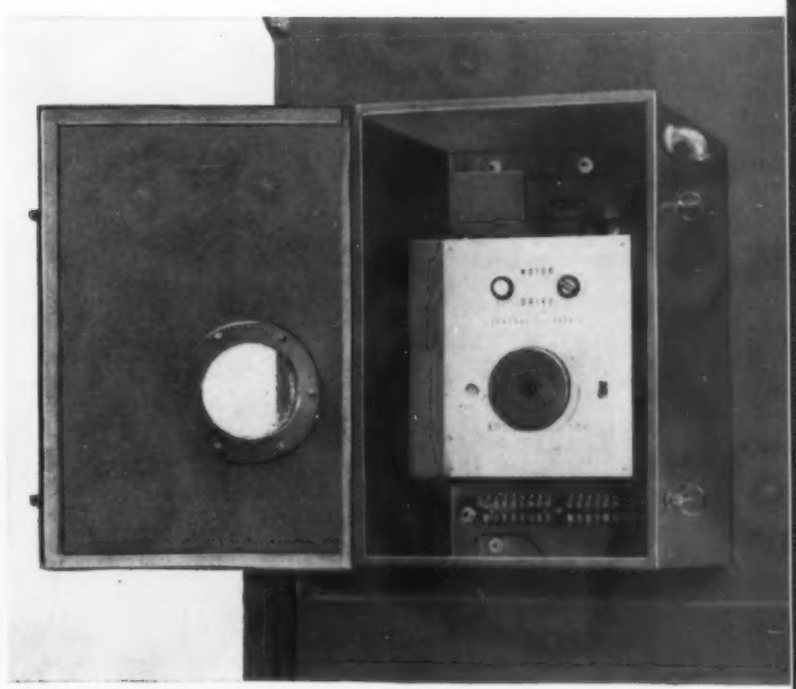
*Reg. trade-mark of General Electric Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC

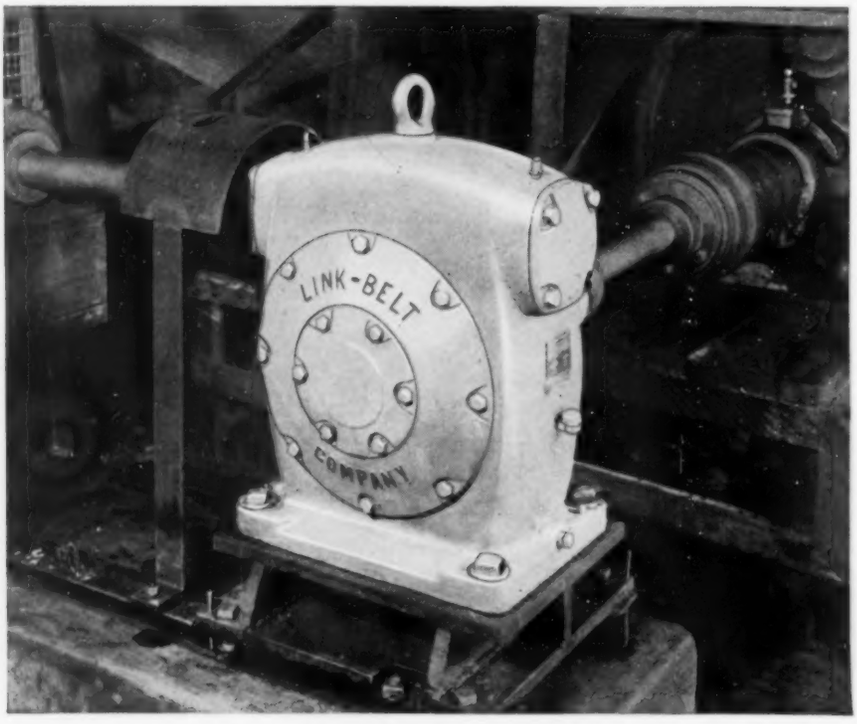


CONVENIENT TERMINAL BOARD saves time in pre-selecting voltages. Nitrile rubber cover gaskets are completely reusable, requiring no surface preparation or cement.



TAP CHANGER DRIVE is electrically and mechanically interlocked to prevent operation with the transformer energized. Dynamic braking assures exact positioning—requires no adjustments.

Here's industry's most comprehensive line of WORM GEAR DRIVES



Reel at the wind-up end of paper machine is driven through a dependable Link-Belt Worm Gear Drive.

FOR efficient, high-ratio, right-angle speed reductions, choose from the complete Link-Belt line of worm gear drives. A wide selection of single-worm, double-worm and helical-worm gear reductions assures you of the best drive for large and fractional horsepower requirements.

All three types are available with horizontal and vertical housings to permit convenient, compact connections to prime movers and driven machinery. And a choice of two shaft diameters facilitates direct connection or the accommodation of heavy overhung loads.

Single Worm Gear Drives are offered in ratios from $3\frac{1}{10}$:1 to 100:1 with output capacities up to 97.9 hp.

Helical Worm Gear Drives are available in ratios from 26:1 to 540:1 — output capacities up to 56.7 hp.

Double Worm Gear Drives have ratios from 26:1 to 8000:1—output capacities up to 26 hp and 124,800 inch pounds torque.

Get all the facts on Link-Belt Worm Gear Drives. Contact your Link-Belt office or authorized stock-carrying distributor. Or write today for Book 2324-A.

Type WB — Single reduction, worm below gear, horizontal output shaft.

Type WV — Single reduction, vertical output shaft (up or down).

Type HWB — Helical gear first reduction, worm gear final reduction. Worm below gear, horizontal output shaft.

Type HWV — Helical gear first reduction, worm gear final reduction. Vertical output shaft (up or down).

Type DWB — Double worm reduction gear, horizontal output shaft.

Type DWV — Double worm reduction gear, vertical output shaft (up or down).

Type WVS — Single reduction, worm on top of gear, horizontal shaft with screw conveyor flange.

Type WVT — Single or double reduction overhead conveyor drive.

LINK-BELT

ENCLOSED DRIVES

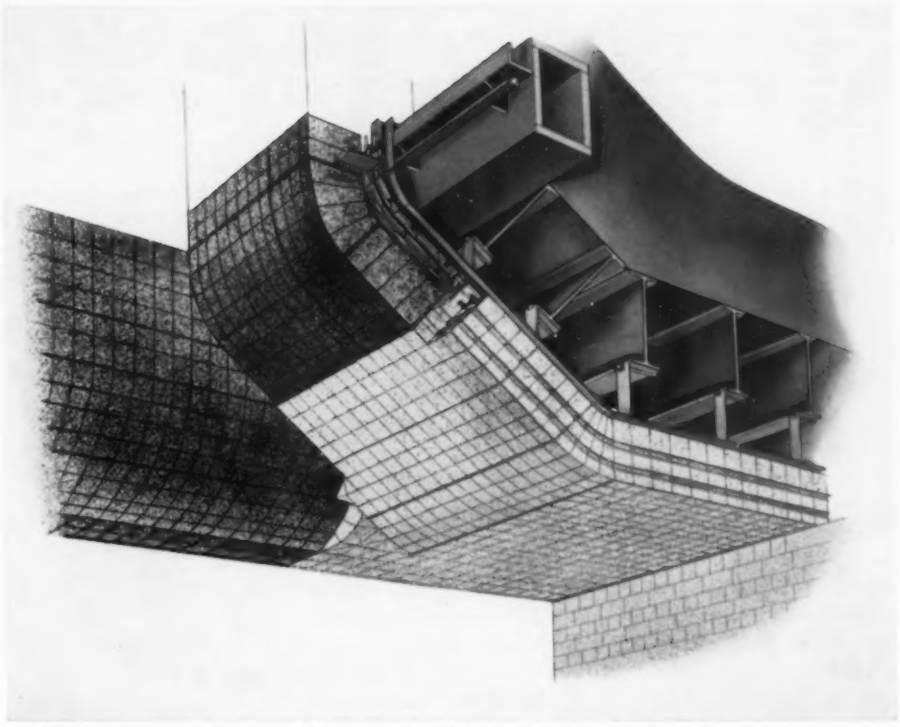
13,073

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

(*Continued from page 198*)

labor saving, in hot metal spouts which handle Bessemer metal in a large steel mill, with the spouts lasting as much as 31 ladles before burning out. In ladle bottoms, tests indicate the brick will release skulls that form in the bottom, without disturbing the brick work.

The brick is characterized by low porosity, negligible shrinkage, and extremely uniform structure. The brick are furnished unburned, ready to be laid up with a graphite base mortar.



FURNACE ARCH

▲ A new interchangeable type arch patented and job proven by more than one year of heavy duty steel mill service, has just been placed on the market by Laclede-Christy Division, H. K. Porter Co., Inc.

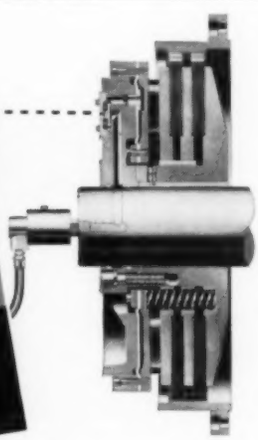
The growing demand for a type of suspended arch construction adaptable to take either basic or clay tile has led to the development of this new type of arch. Basic tile or clay tile may be interchangeably hung on the supporting structure. More or less basic tile may be used subsequently on this same structure as may be indicated by the results obtained in actual service.

Basic tile (magnesite or chrome magnesite) is used to resist erosion from basic slags found in open hearth furnaces in steel mills. It is relatively expensive and hence it is desirable to use this material only in the critical areas. Basic tile has a much higher coefficient of expansion than clay tile, hence a very flexible construction must be provided to accommodate both types of refractory material.

Some of the features of this new design are: adequate provision for

NEW

DODGE AIR-GRIP CLUTCH



— Amazing Sensitivity!

Less air is used to operate the Dodge Air-Grip. The result is a new sensitivity that enables the operator to "inch" the clutch, or to throw it into full engagement, as required. Quick release valves are built into the clutch itself as optional equipment. Air-Grip's unique design places the air seal disc at the end *farthest* from the pressure plates, which generate the heat. This, with automatic internal ventilation, insures cooler operation, longer life. **WRITE** for Bulletin.

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FAST···LEGIBLE BILLET MARKING!

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MODEL 701 PNEUMATIC BILLET MARKER

This new, compact unit stamps ends of billets 4" x 4" or larger with a deep, legible mark as shown above. Unit is mounted on an I-beam track and powered by heavy duty air cylinder. Quick change type holder is kept in stamping position at all times without special guides.

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THE MORE YOU MOVE, THE MORE YOU SAVE... WITH EXIDES!

EXIDE-POWERED ELECTRIC TRUCKS WORK FULL-SHIFT WITH NO UNSCHEDULED DOWN-TIME. TRUCK OPERATION IS SMOOTH, SPOTTING IS PRECISE - WITH NO NOISE OR FUMES. BUT BEST OF ALL, THE MORE MATERIALS YOU MOVE, THE MORE SHIFTS YOUR TRUCKS WORK, **THE MORE MONEY YOU SAVE** - CONSIDERING EXIDE'S LOWER COSTS TO OPERATE, MAINTAIN AND OWN! YOUR EXIDE ENGINEER HAS A SLIDE CHART BASED ON THOUSANDS OF HOURLY COSTS FOR POWERING INDUSTRIAL TRUCKS. ASK HIM TO PROVE THAT EXIDE-IRONCLADS ARE **YOUR BEST POWER BUY - *AT ANY PRICE!***

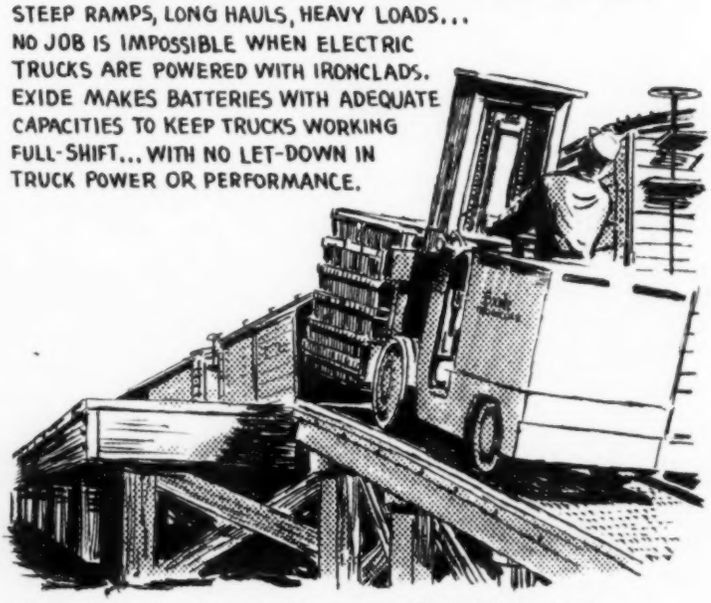
TUBES OF POWER

INSIDE EVERY IRONCLAD ARE SLOTTED TUBES THAT KEEP THE ACTIVE MATERIAL IN FIRM CONTACT WITH CONDUCTING GRIDS OF THE POSITIVE PLATES. THE ELECTROLYTE FLOWS EASILY THROUGH THESE NON-CORRODING SLOTS TO REACH MORE ACTIVE MATERIAL FASTER. RESULT: AN IRONCLAD DELIVERS GREATER POWER... FOR A LONGER TIME... AT LOWEST COST!

PROTECTED SILVIUM® CONDUCTING GRID
COMPRESSED ACTIVE MATERIAL
SLOTTED POLYETHYLENE RETAINER TUBE

NO MOVING JOB IMPOSSIBLE!

STEEP RAMPS, LONG HAULS, HEAVY LOADS... NO JOB IS IMPOSSIBLE WHEN ELECTRIC TRUCKS ARE POWERED WITH IRONCLADS. EXIDE MAKES BATTERIES WITH ADEQUATE CAPACITIES TO KEEP TRUCKS WORKING FULL-SHIFT... WITH NO LET-DOWN IN TRUCK POWER OR PERFORMANCE.



LET EXIDE HELP SOLVE YOUR INDUSTRIAL TRUCK BATTERY PROBLEMS. ❶ CALL AN EXIDE SALES ENGINEER FOR FULL DETAILS. ❷ WRITE FOR FORM 1982, A MANUAL ON INSTALLING AND MAINTAINING MOTIVE POWER BATTERIES.

Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

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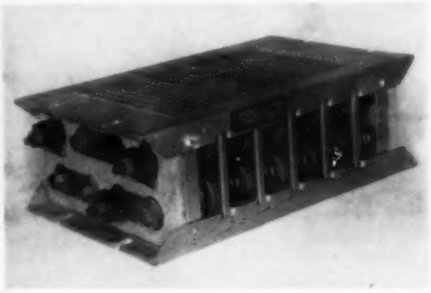
Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

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Cleveland, Ohio—Mechanical Equipment Co. 3100 Prospect Ave.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

Pittsburgh 27, Pa.—P. R. Holden, 4860 Elmwood Dr.

●

GUYAN MACHINERY COMPANY

LOGAN, W. VA.

expansion and/or growth of tile heating up and continued service in the furnace; ease of installation; tongues and grooves in clay tile hold mortar in place and provide better seal; steel encased basic tile with corrugated steel strips in expansion joints provide room for expansion and seal the joints, and a minimum number of tile shapes are required.

Book Reviews . . .

"Electrons, Atoms, Metals and Alloys," by William Hume-Rothery, has just been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 385 pp., is 5¼ x 8¼-in., cloth bound and sells for $10.00. This book is divided into four parts dealing with structure of atoms, metals, alloys and atomic nuclei and is written in the form of dialogue between an older metallurgist and a young scientist thus presenting a clear contrast between the old and new ideas. This can also serve to many as an elementary introduction to modern atomic theory although it is written primarily for the metallurgical reader.

"Metals Reference Book," has recently been published in a second edition in two volumes, by Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y. Volume I contains 531 pp., Volume II contains 967 pp., both are cloth bound with pages measuring 6 × 10-in. selling for $25.00 per set. This reference book is written to provide a convenient summary of data relating to metallurgy and metal physics. The information is presented in the form of tables or diagrams in order to better illustrate the data. This second edition has given a very thorough revision of this subject which has been greatly enlarged and expanded. New values are included to check with latest available data.

Two hard-cover books which may be described as catalogs have just been published by Lukens Steel Co. in Coatesville, Pa. They contain detailed information, technical data and prices of both clad steel head and carbon and alloy spun heads. They elaborate on estimating sizes, tolerances and weights, and can be found helpful to all users of steel plate, espe-

Hyde Park

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Gray Iron Castings

Hyde Park Castings up to 80,000 pounds are sound, accurate and physically dependable.
Precision machining is done by skilled craftsmen in our modern machine shop.
Send your blue prints for quotation.

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Machine Castings
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For finer finish, long life and greater tonnage, specify Red Circle Rolls.

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ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

VICTOR R. BROWNING

Mill Type Cranes

TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

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DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

cially engineering, design and purchasing personnel. The books may be ordered through the Marketing Service Office of Lukens Steel Co., Coatesville, Pa., at $3.00 each.

"Everything and the Kitchen Sink," by Farrar, Straus and Cudahy, Inc., was recently published by The Philip Lesly Co., 100 West Monroe Street, Chicago 3, Ill. It contains 160 pp., 7½ × 10½-in., cloth bound and sells for $4.00. This book shows how American industry has revolutionized in just one century American life by constantly seeking for better ways to do things, and portrays a story of ingenuity, initiative and foresight. The book is published in commemoration of the Centennial of the Crane Co., and its founder Richard Teller Crane.

"Hydraulic Operation and Control of Machines," by Ian McNeil has recently been published by The Ronald Press Co., 15 East 26th Street, New York 10, N. Y. The book contains 324 pages, 5½ × 8½-in., is cloth bound and sells for $7.50 per copy. This book is an up-to-date practical aid to firms and individuals specializing in various aspects of hydraulic machinery. The book discusses the subject of hydraulics, not from the civil engineer's viewpoint, but from the standpoint of the mechanical engineer who uses hydraulics as a means of transmitting power and of controlling mechanical movements. Descriptions of many hydraulic machines and devices are covered.

"Metal Statistics 1955," was just published by the American Metal Market, 18 Cliff Street, New York 38, N. Y. It contains 864 pp., 6 × 4-in., cloth bound, and sells for $3.50 per copy. This is the 48th annual edition of this handy standard statistical reference book for the iron, steel and metal industries in Canada, the U. S., Mexico and Japan. It contains up-to-date and historical records of production, consumption, stocks, imports and exports, monthly and annual market prices plus valuable data on allied economic subjects.

"Vapor-Plating," by C. F. Powell, I. E. Campbell, and B. W. Gonser was recently published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 158 pages, 6 × 9-in., is cloth bound and sells for $5.50. This publication is a critical and authoritative review of the applications and techniques of vapor deposition of metals and non-metals and provides data and information on these processes. It also gives a complete description of present and past applications of these techniques which are not too widely known.

"Asbestos, Asbestos-Varnished Cloth and Asbestos-Thermoplastic Insulated Wires and Cables," Nema Publication No. WC 1-1955, has recently been published jointly by the American Standards Association, the Insulated Power Cable Engineers Association and by National Electrical Manufacturers Association. It contains information on the construction, identification, insulation and testing of the following types of wires and cables: A, AA, AI, AIA, AVA, AVB, AVL and TA. This is paper bound and sells for $3.00 a copy. Copies may be obtained from National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

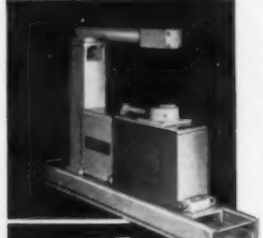
Call or Write STAMCO for...

Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

Keep production up with
AIRE-RECTIFIERS
the original Split System
CRANE CAB CONDITIONER
for Crane Cabs and Pulpits
THE LINTERN CORPORATION
ROUTE 20, EAST • PAINESVILLE, OHIO

"MEASURAY"
MEASURES THICKNESS ACCURATELY *without TOUCHING the MATERIAL*



Hot or Cold Strip Steel, Brass, Copper, Aluminum . . . Plastics, Foils, Coated Fabrics, Film, Rubber, Etc., Even When Moving At High Speed.

Simple method—the "Measuray" shoots X-Rays through the material—measures its absorption of the rays. Calibrated meter registers plus or minus per cent of deviation from pre-determined standard. Especially useful on hot mills where material can't be checked by contact gages. Also when material can be deformed by contact such as foil.

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MANUFACTURE AND MEASUREMENT FOR MANKIND

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A De Laval-designed mill lubrication system assures you . . .

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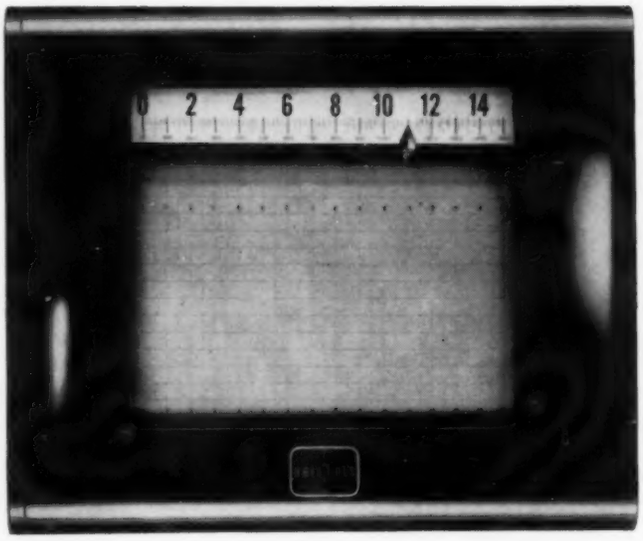
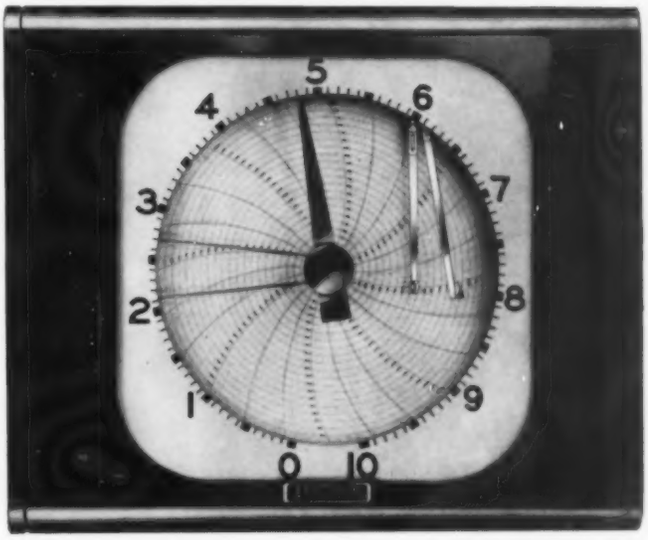
WHAT'S NEW AT BRISTOL...

Three Ways to Better Temperature Control





BRISTOL ELECTRONIC DYNAMASTER® POTENTIOMETERS

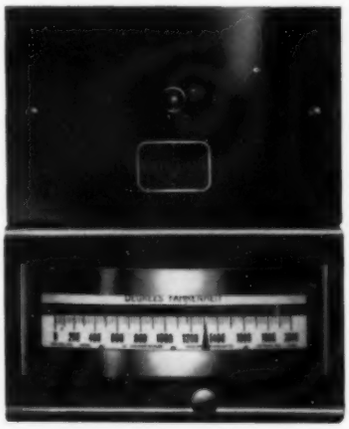
CONTINUOUS STANDARDIZATION WITH NO DRY CELLS: Bristol Dynamaster Potentiometers with No-Batt Continuous Standardization which eliminates need for dry cells. Results: no interruption in operation for standardization, no batteries to replace.

A MODEL FOR EVERY REQUIREMENT: Dynamaster Potentiometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

ELECTRIC AND PNEUMATIC CONTROLLERS. Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control — on-off, average position, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control — on-off, proportional, and proportional with reset.



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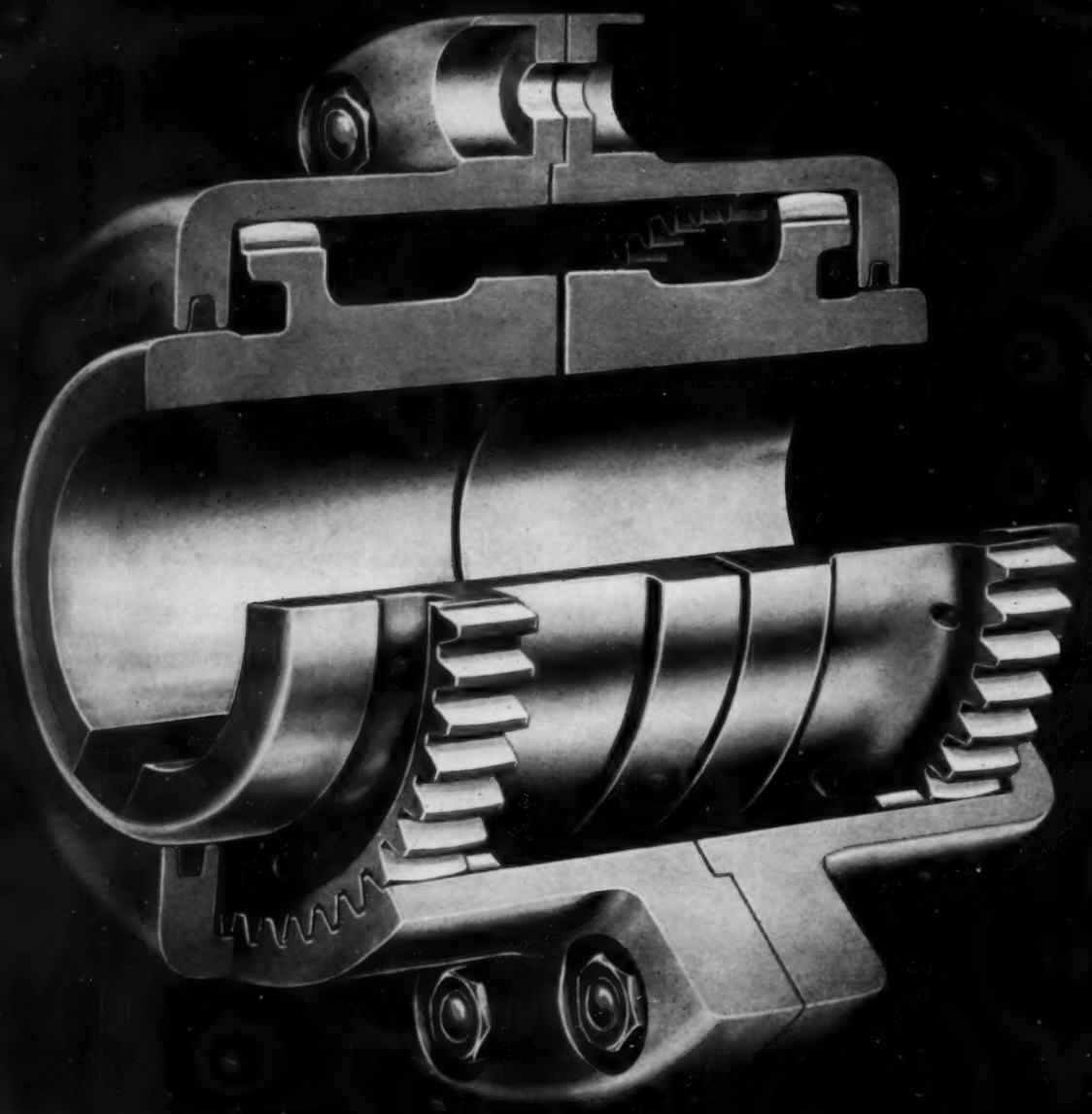

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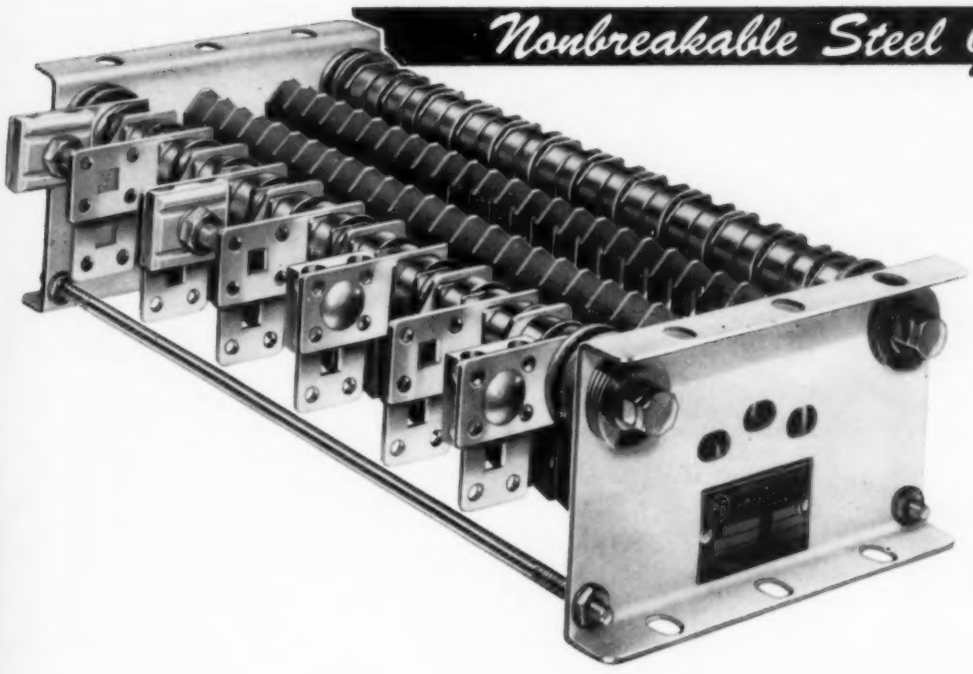

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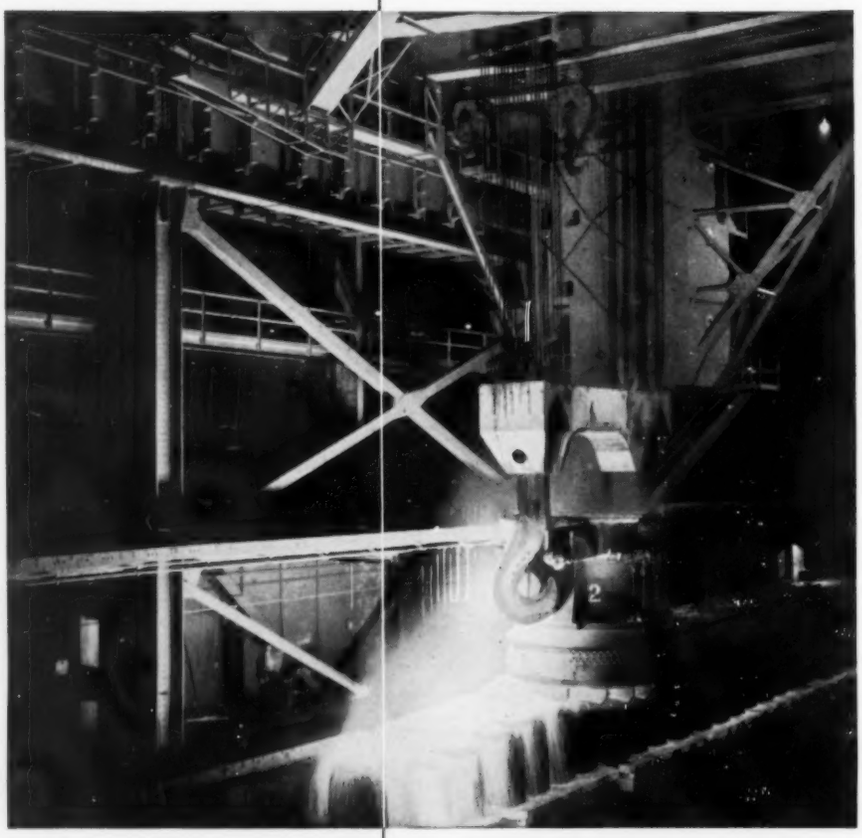
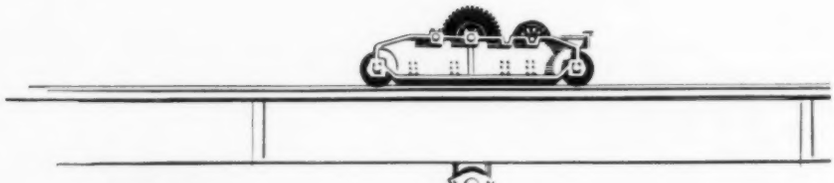


Positive action encourages operators to use the hydraulic brake rather than plug the motor.



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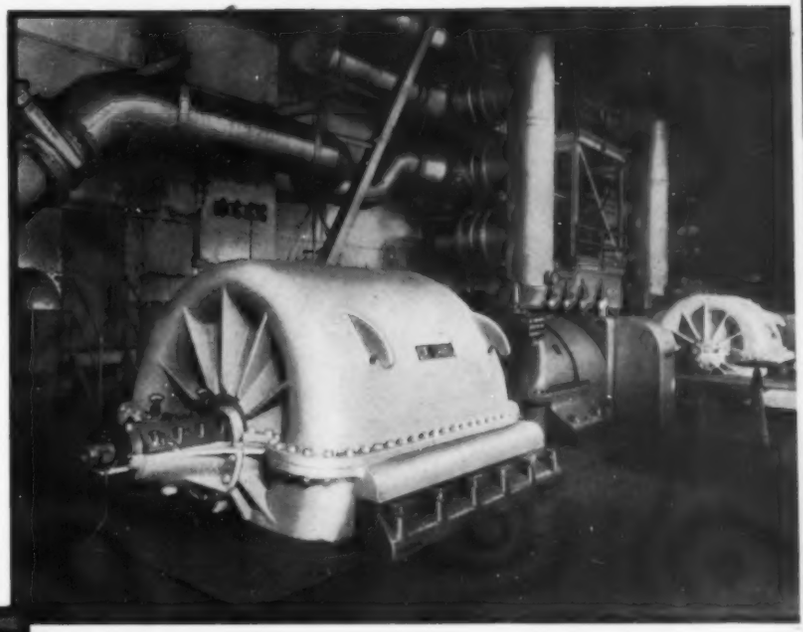
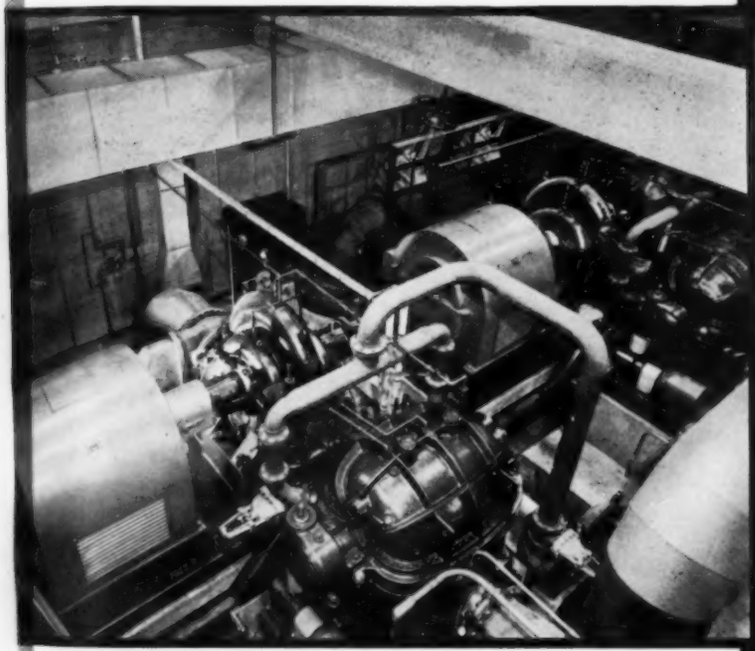
DE LAVAL
CENTRIFUGAL BLOWERS AND PUMPS

stay on the line for years at Jones & Laughlin

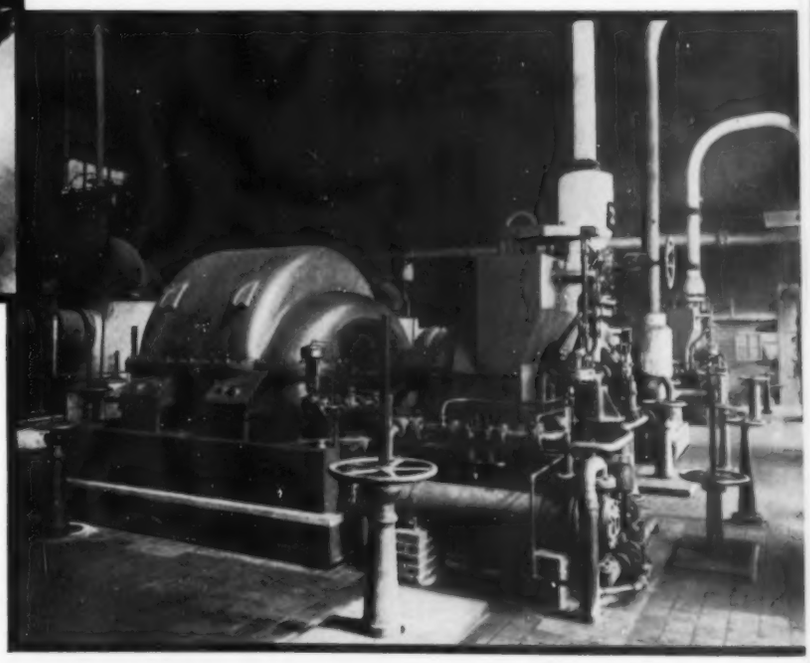


Jones & Laughlin reports: "*We have been using De Laval equipment for many years, and from our experience we have learned that De Laval blowers and pumps are inexpensive to maintain. Service is excellent. We can get spare parts quickly.*"

Three De Laval 22,000 gpm motor-driven pumps are on the job at Jones & Laughlin Steel Corporation in Pittsburgh, Pa. These units are used to pump river water to the open hearth and general mill. Installed in October 1951, these three pumps "have not had any downtime at all since their installation except for periodic inspections," Jones & Laughlin reports.



These two De Laval centrifugal blowers, each rated at 100,000 cfm, are in use 24 hours per day, seven days per week except for a yearly inspection period. Since installation, there has been only 24 hours downtime in one of these blowers with a maintenance cost of about $400. "That's very little for this type of equipment," says the Jones & Laughlin blower room foreman.



This is one of three De Laval gas exhausters, operating at 48,000 cfm around the clock. Two of these units can handle maximum capacity; the third is used as a spare. Jones & Laughlin says, "Without good gas exhausters you would have to 'bee hive' (open the top and permit the gas to go free), thus losing our by-product."

Send for Bulletin 0504

DE LAVAL *Pumps and Blowers*

DE LAVAL STEAM TURBINE COMPANY
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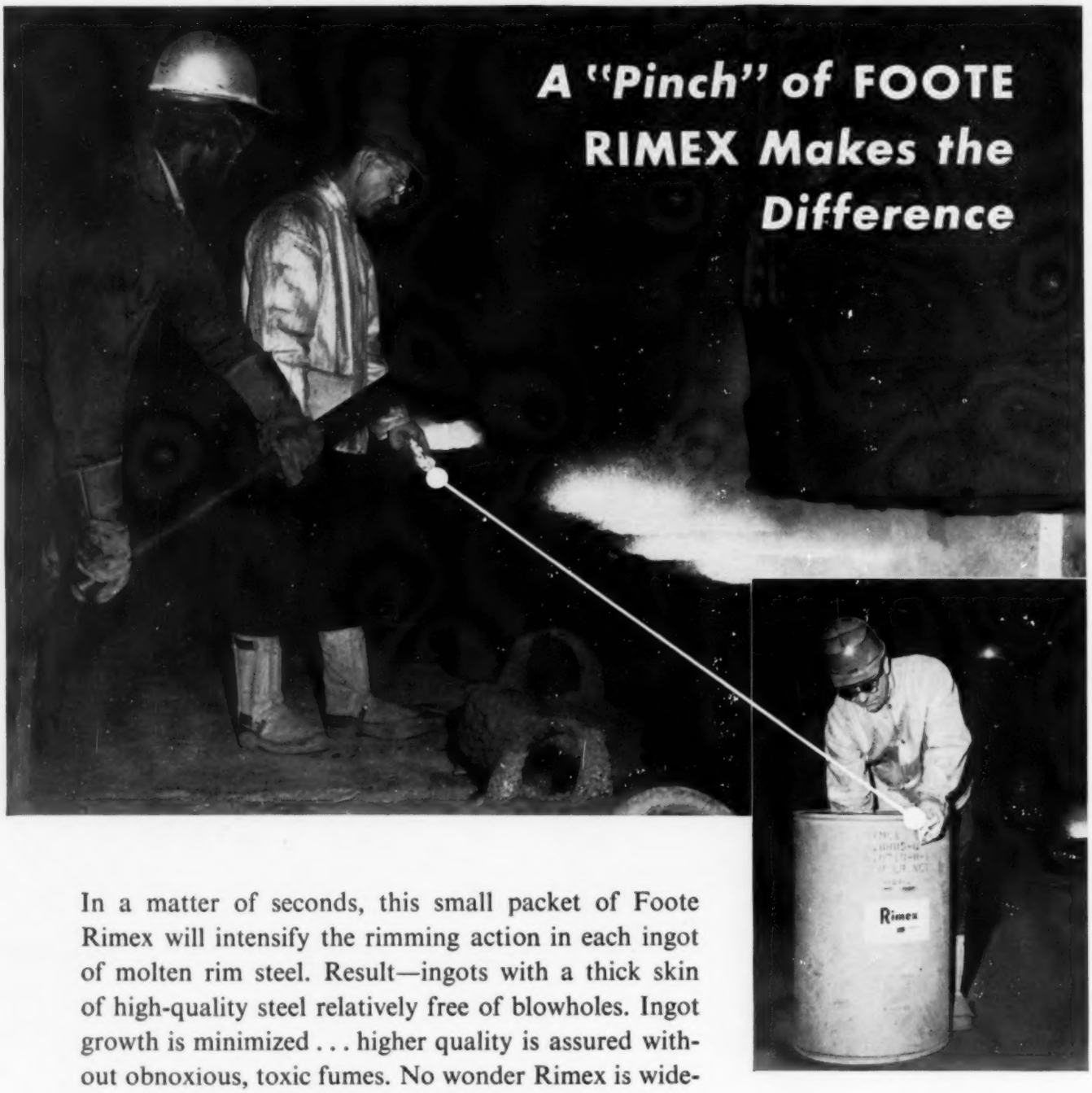
DL 297



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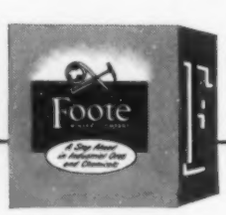
Rimex is one of the specialized additives developed by Foote to meet the needs of the steel industry. Whether you need a new type of steel additive or are interested in the standard additives, it will pay you to contact Foote.

Foote metallurgical engineers stand ready to serve your steel additive needs. A letter will place their experience at your command.



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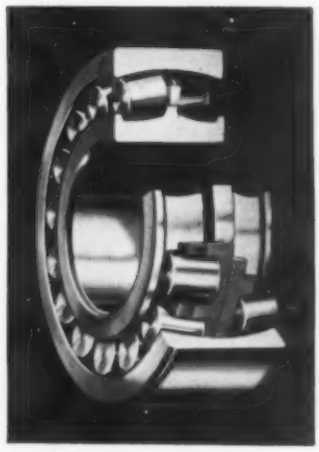

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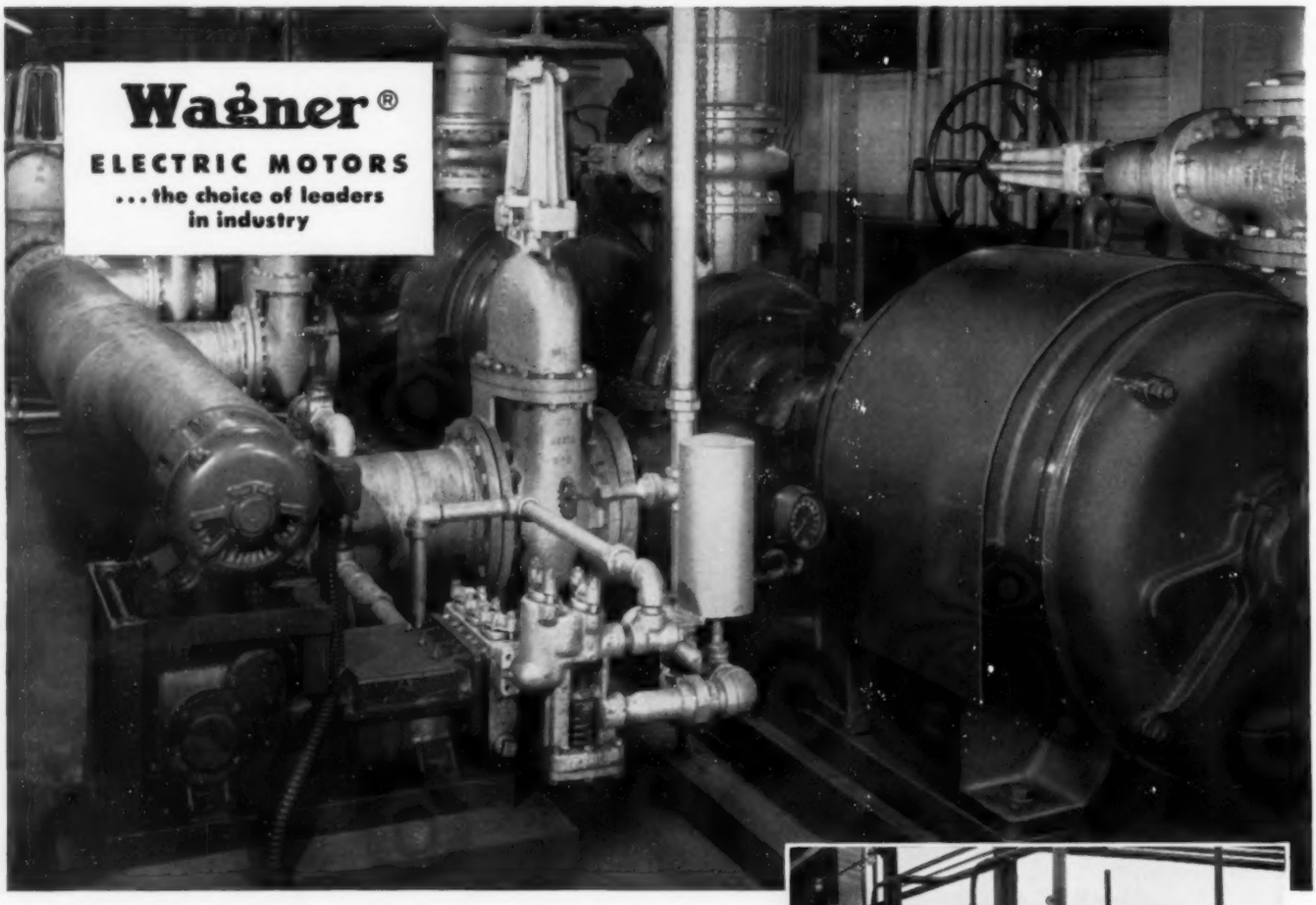
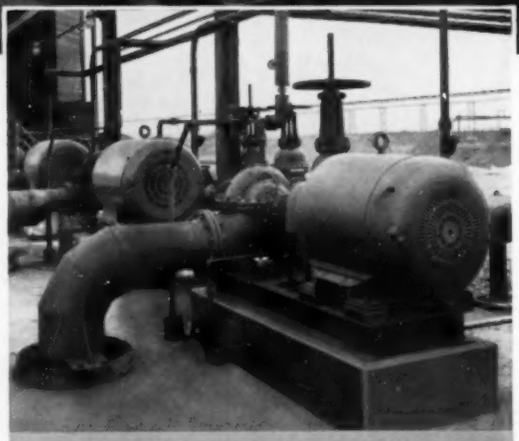


At U. S. Steel's giant Fairless Works, hundreds of Wagner motors drive fans, blowers, pumps, coal breakers and other vital equipment. Shown above are the 300 hp Wagner Type RP motors that operate gas washer pumps at Fairless.

This type of Wagner motor is built in ratings up to 400 horsepower. It is protected by a heavy steel frame with ventilating openings at the bottom only and by endplates of dripproof design. These motors have the winding strength required to stand the shock of starting heavy loads repeatedly and have adequate ventilation to operate continuously without exceeding their 40° C temperature rise.

A skilled Wagner engineer will be glad to help you select the correct motors for *your* specific application. Just call the nearest of our 32 branch offices, or write for Bulletin MU-185 for complete information.



A 60 hp, type CP-1 and two 100 horsepower, type EP-1 Wagner motors driving final cooler pumps in the coal chemical area at Fairless Works coke ovens.

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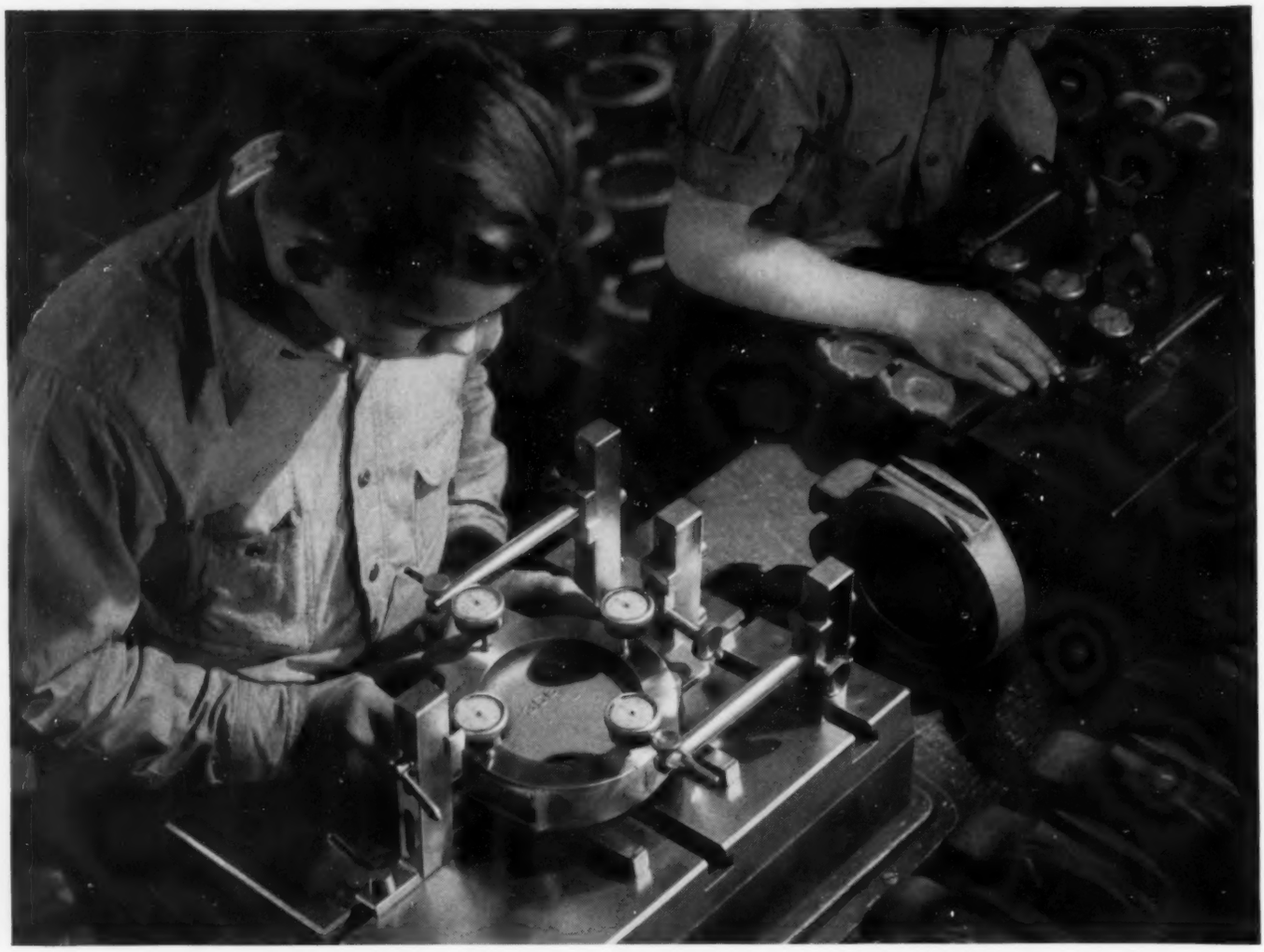

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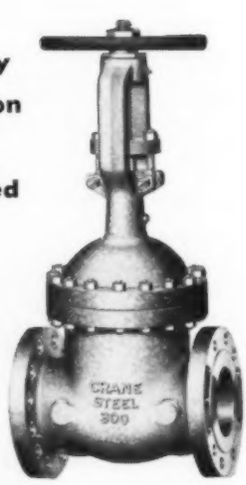

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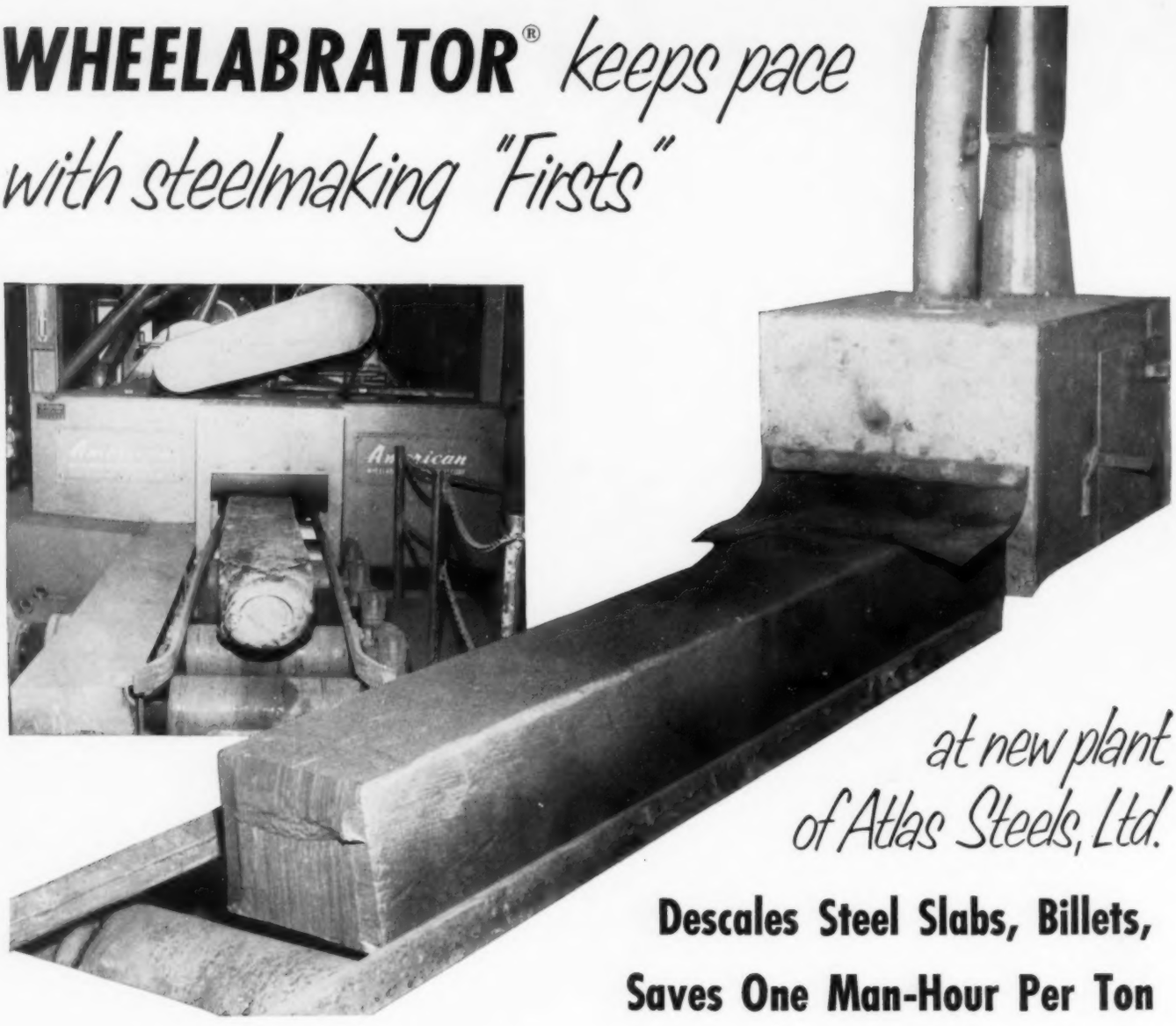
WHEELABRATOR® keeps pace with steelmaking "Firsts"



at new plant of Atlas Steels, Ltd.

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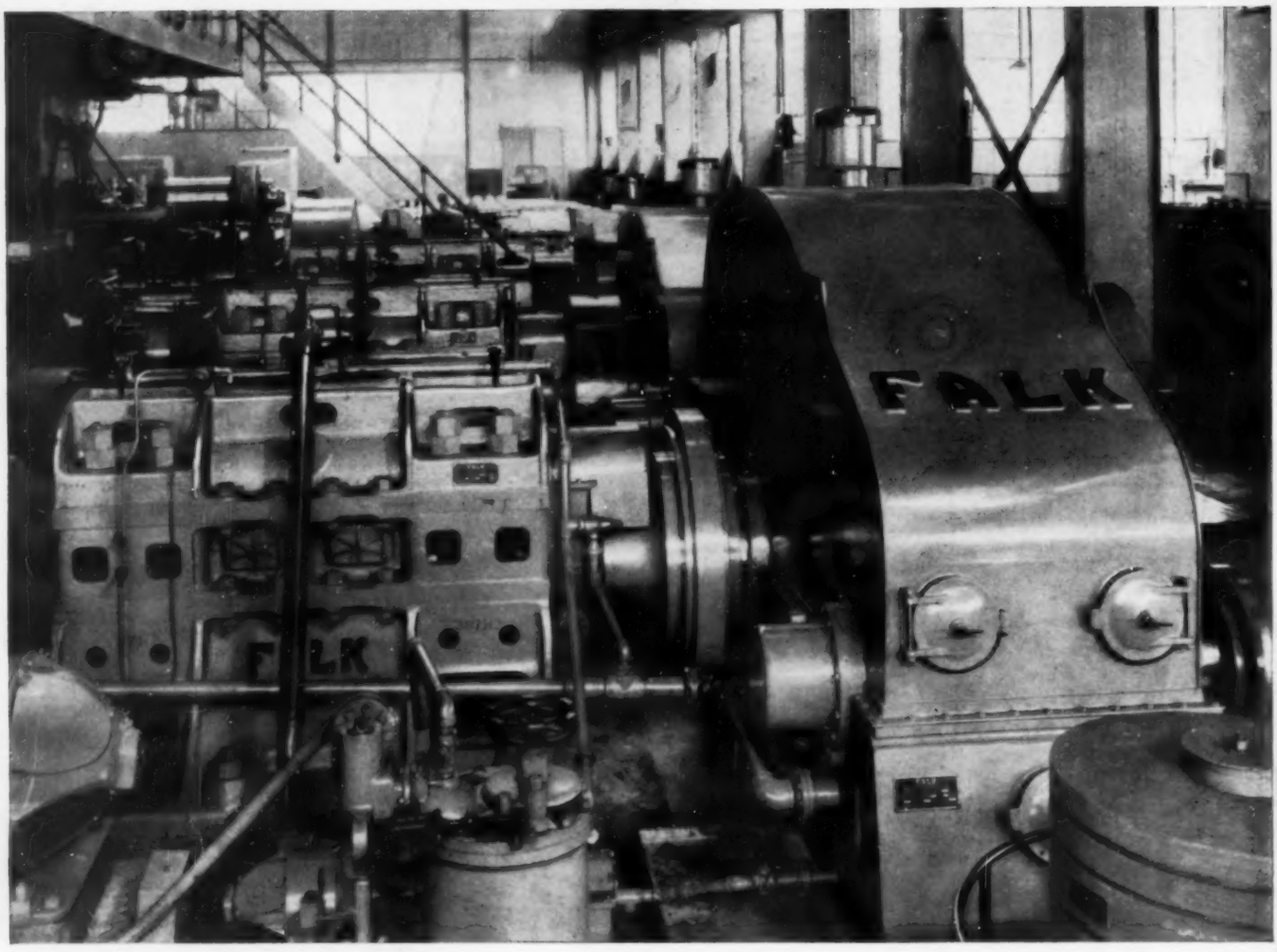

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